THE ENGINEER.

Grinding Machines.

GRINDING MACHINES.

GRINDING is certainly one of the very oldest of arts, but the grinding machine as it is known now-a-days is an essentially modern invention. For some thousands of years man was content to use the grindstone simply for sharpening or polishing, and it is only of late that he has discovered that, properly employed, there is no tool approaching it in accuracy and, work for work, none exceeding it in economy. Twenty-five, even twenty years ago, fine grinding was understood by but few engineering firms, but now-a-days there is not a single well-organised machine shop in the land that has not at least one grinding machine, apart, of course, from those used for the sharpening of tools. The grinding of flat, round or shaped surfaces is now a recognised machine shop operation which competes with turning and milling easily on the score of accuracy, and under certain circumstances even in the matter of speed and cost. Indeed, a few years ago enthusiasts were convinced that fine turning was out-dated, and sought to see the lathe reduced to the very roughest work, finishing being reserved for the grinder. Their anticipations have not been realised. The lathe has easily held its own, and the grinding machine has settled down into its proper place in the economy of the machine shop.

Where great accuracy is required grinding is unapproachable, and the abrasive wheel has, moreover, the virtue of producing a surface which appears to be more durable than that left by a lathe, and on that account very desirable for bearing and running fits. Possibly this fact is due to a certain extent to the accuracy of the product, but it seems accepted that a skilful grinder, by the selection of a suitable wheel and the employment of appropriate speeds and feeds, can produce a finish having superior properties to that left by the lathe. It is, however, on the accuracy of its output that the supremacy of the grinding machine really depends. On small machines one ten-thousandth of an inch is not regarded as too fine a limit, and even on big tools one four-thousandth is attainable with care. Such refinements of measurement are, of course, as inconceivable to the human mind as great distances, but it is brought home to us when we know that a grinder will sometimes, in order to remove the amount of material required, merely warm the work by placing his hands upon it. The degree of expansion produced is appreciated by the machine, and when the piece returns to its normal temperature the diameter is found to have been reduced.

In order to obtain such results as this machines of a very high order of excellence have to be employed. They must in the first place be rigid in all parts; the table and the bed must be free from liability to distort and their bearing surfaces must be of great length. The grinding head must be accurate and its spindle must run truly over a fairly long range of high speeds. The work itself must be properly prepared, and it must be carried between perfectly rigid centres and be capable of receiving, if round, a good range of speeds of rotation. Finally, means must be provided for traversing the work and the wheel relatively to each other at various rates. Means for applying the feed automatically at each end of the stroke may also be provided, but are not essential. These are the general qualifications of a first-class plain grinding machine, of which many examples will be found in the following pages. On one point alone can there be any difference of opinion, and that is as to whether the work or the wheel should traverse. As a rule, there can be little doubt that it is better to fix the wheel, but in some cases, as in the grinding up of long shafts, this is prevented by considerations of space. In such cases the wheel head should be given a very long bearing on the bed, so that it may not wear it away locally, one of the principal objections to the traversing wheel being that it gets out of alignment from this cause. There is the further objection that the operator has to travel up and down with the wheel, and he is unable to attend to the work so well as when both he and it are stationary, particularly with a rapid traverse. The moving wheel is, however, largely used, though the consensus of opinion is in favour of the fixed wheel head and moving work where circumstances permit.

A very important matter where minute dimensions are being dealt with is that the centres should be rigidly in line, and it will be seen that nearly all grinding machines have a special form of shear to which the poppet heads are fixed, the rule being that both heads shall be guided by a single vee or surface against which they are pulled by the locking bolts. The shear must also be adapted to support the steadies—most important items in grinding long work—which should be readily removable and easily adjustable. An examination of the illustrations and descriptions which follow will show how these various features are realised in practice; but before turning to actual machines it is desirable to say a few words about the art of grinding and grindstones—or, as they are now called, wheels—themselves.

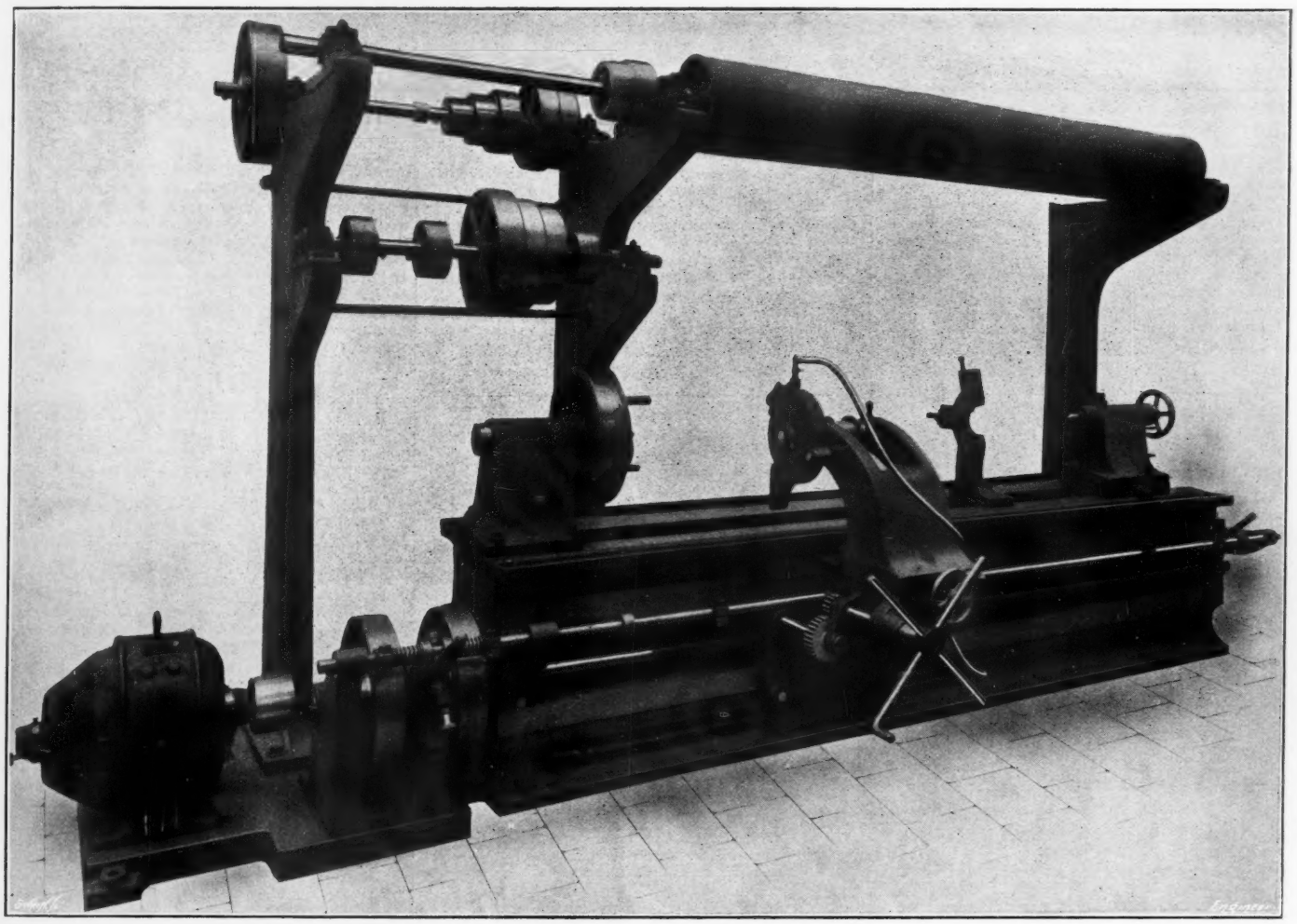


FIG. 1—HULSE AND CO.'S PLAIN CYLINDRICAL GRINDER

The grindstone has been described as a milling cutter with an enormous number of teeth. That definition is accurate as far as it goes, but to make it complete, we must add that the teeth are "inserted," and that they renew themselves automatically. Keeping these points before us, much of the mystery of grinding becomes clear. We see at once how the maximum cut of a wheel is limited. Consider any grain or kernel of an abrasive wheel. Suppose, for the sake of argument, that it is $\frac{5}{100}$in. long. Of this length only one-half can project, the remaining half being embedded in the matrix to give it support. We thus get a tooth $2\frac{1}{2}$/100ths long, and that is the maximum depth we can cut at each revolution of the wheel. Or again, if we bear in mind that in order to keep the wheel

sharp we must maintain a regular breaking away of the blunted kernels, we see the reason why a softer wheel must be used on a large diameter or on a flat surface than on a small diameter, for it is clear that if we are cutting a flat surface the area of contact is larger than if we are grinding one of sharp curvature, and it is more difficult for the particles to break off. If we consider the case of the diamond point used for trimming or trueing a wheel, we see the case carried to its limit. The diamond point digs into the matrix and breaks away the hard material freely; we could never do the same thing with a flat-ended tool. *vice versâ* under both circumstances; but there are a great many grades of stones, and a good many surface speeds at which they may be run, and every change affects the result. Then, again, the grinder has to consider the size of kernel in his wheel. All wheels are made up of grains of some abrasive material—emery, carborundum, alundum, and so on—sifted down till they are all of uniform size, and then mixed with some suitable material into a paste and moulded into the shape required. Now-a-days wheels are, as a rule, vitrified—that is to say, they are submitted to intense heat in a furnace until the matrix runs into a hand, a great deal of very high-class experience has been put into the design of machines, and they have reached the great degree of excellence that is required to ensure the very minute accuracy expected from them. This fact has no doubt contributed not a little to the increased facility of grinding.

Mr. Darbyshire, in his excellent little treatise on Precision Grinding, sums up the whole philosophy of the cut very neatly thus:—"A coarse wheel may be unsuitable because the area of the projecting kernels may be too large to enter the surface of the work without an undue

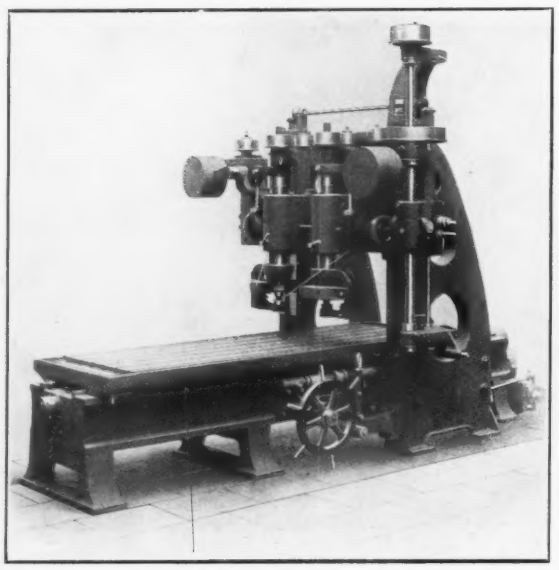


Fig. 2—HULSE'S PLANER TYPE FLAT GRINDER

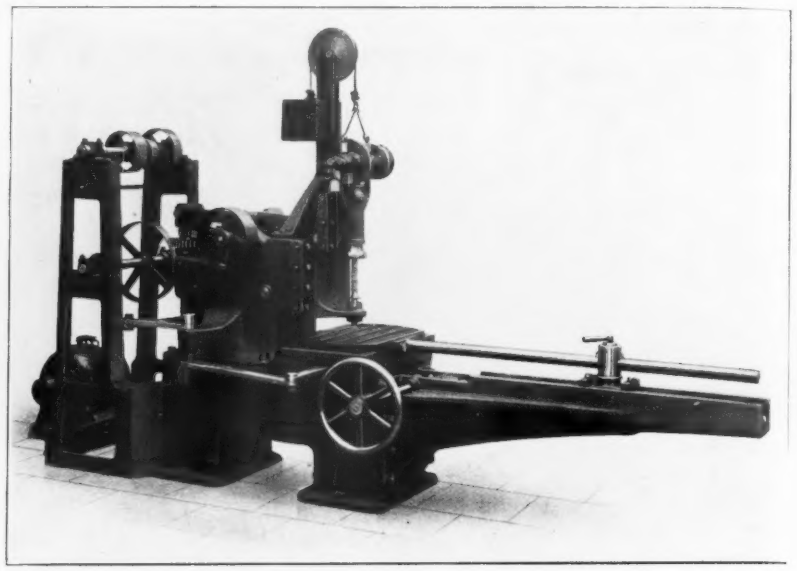


Fig. 3—HULSE'S LOCOMOTIVE LINK GRINDING MACHINE

Of course, there are other agencies at work also, and it is by ringing the changes on them that a skilful grinder gets the best results from his material. He may, for example, vary the speed of rotation of his wheel or the speed of rotation of the work, or both. It sometimes happens that a wheel glazes, particularly when grinding cast iron. In that condition it ceases to cut, and burns a brown mark on the work. The wheel must then be trued with the diamond, and if it is run at a slower speed will cut properly; if not a softer sort of glass which cements all the kernels together. Various sizes of grit are used, generally known by the size of the mesh through which they will pass—as 27 to the inch, for example—but the material used for the matrix has also different degrees of hardness, distinguished by letters. We thus get a wheel, for example, such as 27 K, the figure telling the size of the kernels and the letter the degree of hardness of the matrix. The kernels themselves may be all from precisely the same material and all of the same hardness, irrespective of amount of pressure. A wheel should always cut freely, even with the lightest depth of cut, for if we have to use any pressure in the last or finishing cuts, we are likely to either overheat and so distort the work, or else disturb the method of holding it which has been adopted to attain accurate results. For grinding glass a wheel of 150 to 200 grit is necessary, because grit of a larger area cannot be made to enter the surface, and very hard chilled rolls require a similar wheel for finishing for the same reason. Cast iron when highly finished bears some relation to the latter materials, and though it may be finished up to a certain point with a fairly coarse wheel, the wheel will refuse to cut when the kernels are dulled or their area is too large."

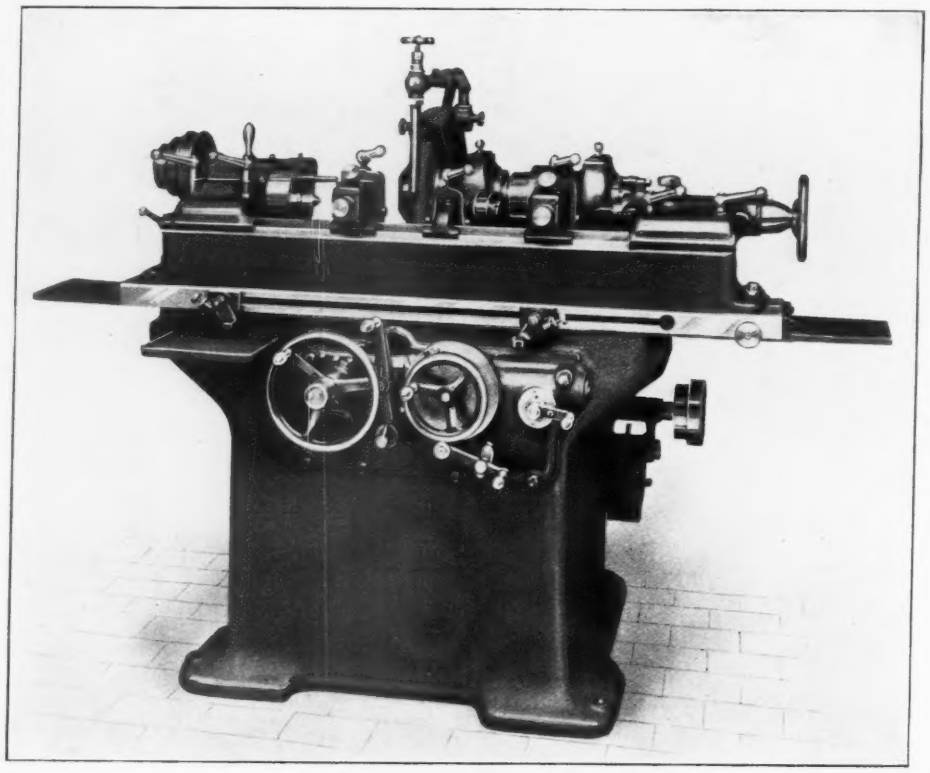


Fig. 4—WARD'S PLAIN GRINDER

Besides the speed of rotation of the wheel and the work, and the grade and character of the wheel, the grinder has to study the question of traverse. His object, of course, is to turn out the work as quickly as he can consonant with the degree of accuracy and the nature of the finish required. Clearly, then, the more rapid the traverse the

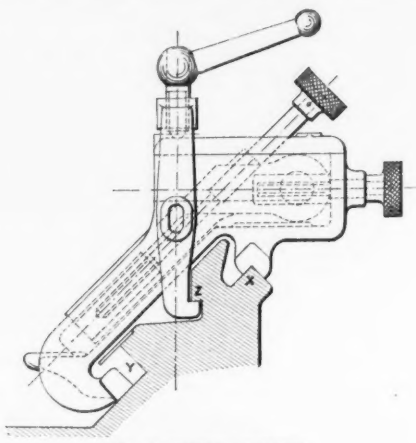


Fig. 5—WARD'S STEADY

wheel must be tried—a wheel, that is, that sharpens itself more easily. Grinding is full of little problems of that kind, and it requires a considerable practical experience, and a mind quick to grasp the cause of a defect and to suggest a remedy, to make a good grinder. The operator must keep before him the fact that in order to ensure good clean cutting his wheel must break away regularly, exposing new sharp teeth, and the problem he has to face is to find out the grade of wheel that gives the required result on materials of different hardness and different diameter. With a large diameter a soft wheel must be used, with a soft material a hard wheel, and size. It is easy with a sharp instrument—the corner of a file, for example—to tell by scratching the surface whether a wheel is hard or soft, and an experienced man can even estimate the degree of hardness by this method. There is, it appears, still some uncertainty about the process of vitrifying, and makers are not certain of the result that any given conditions will produce, but, nevertheless, the old complaint that it was difficult to get uniform wheels is no longer true; all reputable makers supply wheels which are true to grade. This has greatly simplified the art of grinding, as it has removed one element of uncertainty. On the other better, but rate is regulated by several factors. In the first place, it cannot be greater than the width of the wheel. The reason of this may not be obvious at first sight, but let the wheel be regarded, as it justly may be, as a single fixed tool, and it will be seen at once that if the traverse is greater than its width a rough projecting spiral will be left upon the work. As a rule, then, the traverse is less than the width of the wheel, but where it is desirable to remove stock rapidly the traverse may be up to the full width, and with that object in view it is a good plan to make, as some makers do, the side feed independent of the speed of rotation of the work. At what speed the wheel should move for finishing can be settled by no definite rule, save that for very fine finish, a fine cut and a slow traverse are generally considered to give the best result. The object, as a rule, is to avoid anything like spiral marking on the work, as its appearance is often considered objectionable. That it has really any objectionable properties seems highly improbable, in view of the fact that the difference in the diameter made visible by it is immeasurably small. Indeed, some people have said that, if anything, such inequalities are valuable in bearings, as they give the lubricant a better chance of

spreading over the surface. The plea may be good, but it appeals to but few grinders, who prefer to see the work left perfectly free from all marks save the curious grain that is quite characteristic of a ground surface, and even this for bearings is frequently removed by a light touch with the finest worn-out emery paper or by lapping.

Another very important question is whether the work shall be ground dry or wet. At one time such an objection was felt to sousing beautiful machinery in water that nearly all grinding was done dry. Now-a-days, however, opinion has changed, and practically all cylindrical work is done with a copious supply of water. Flat work, on the other hand, is, as a rule, still ground dry. In such cases it is highly desirable to provide means for carrying off the fine sharp dust produced. It may be caught on wet cloths hung up in front of the wheels, but a better plan is to provide suction mouthpieces and fans to carry it away. But where possible it is probably best to work wet. Wet grinding, besides having the advantage that this trouble is avoided, is better also for the more important reason that distortion of the work due to local heating is prevented, and the improvement in the means of applying the water, of confining it to certain parts of the machine, and of carrying it back to the sump have been so greatly improved of late years that there is no real objection to it any longer, and wherever it can be employed there should be no hesitation about employing it. A small fact in connection with it, interesting enough to mention, is that the jet requires to be properly designed, or the water will be thrown away from the wheel by the currents of air that leave it as they would a fan. The jet should be the full width of the wheel, and should be applied as near as possible to the point of contact of wheel and work.

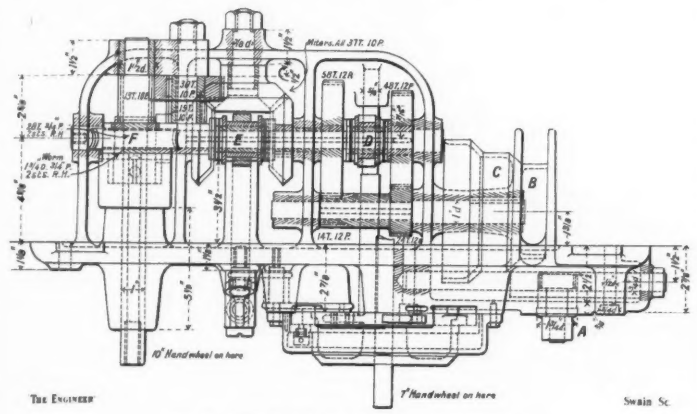


Fig. 6—APRON OF WARD'S PLAIN GRINDER

We turn now from general matters to machines themselves In preparing this Supplement we have endeavoured to give a good general idea of the scope of grinding machines, and for that reason we have selected a very large variety of types extending from little machines kept exclusively for the sharpening of twist drills up to big machines for grinding heavy shafting or railway wheel tires. We have also introduced a few special types, such as machines for grinding crank pins, the links of valve motions, the heads of ogival shots, and so on, and we have not omitted the special form known as the disc grinder. We do not pretend that all the uses of grinding machines are covered, but we believe that the following pages will give the reader a very just idea of the scope of grinding and of the various forms, types, sizes, and construction of grinding machines.

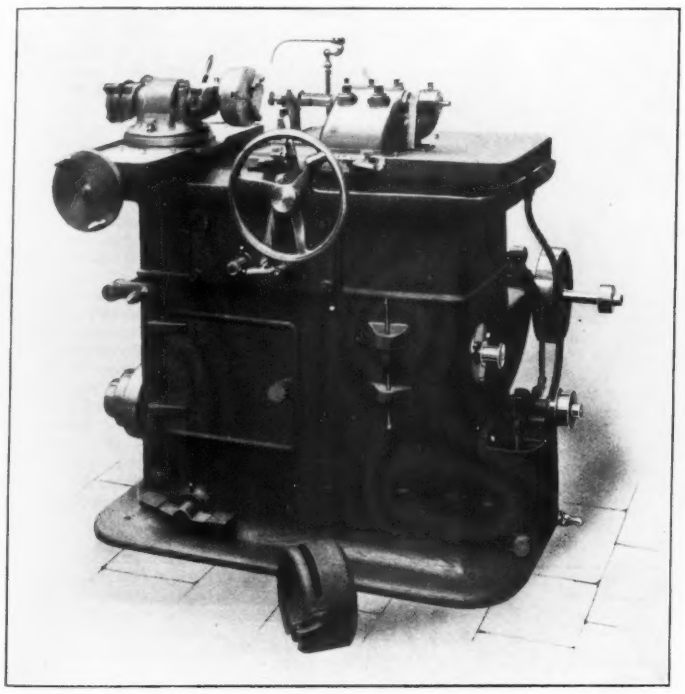
In concluding this brief introduction we desire to express our thanks to the various makers who have assisted us in its preparation, and particularly to Alfred Herbert, Limited, of Coventry, who gave us the opportunity of studying, under the guidance of Mr. Shaddock, their courteous and able grinding shop foreman, the latest developments of precision grinding.

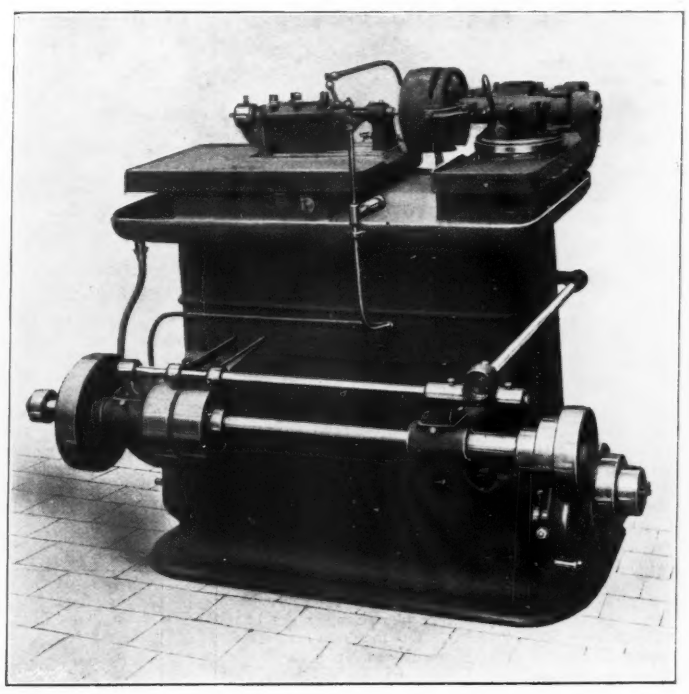
The machine illustrated in Fig. 1 has been specially designed by Hulse and Co. for plain cylindrical grinding, either parallel or taper. It is of heavy and rigid construction, the bed having ample vertical bearing surfaces at the front for the sliding carriage. Two headstocks are fitted on the bed, one fixed and provided with a driving pulley and a Clement's driver for rotating the work upon dead centres, the other being adjustable along the bed and having a transverse slide permitting of tapers up to 1 in 24 on the diameter being ground. The sliding carriage is traversed along the front of the bed automatically in either direction through reversing pulleys, a guide screw, and double clasp nut. There is also a quick hand adjustment by means of rack and pinion. The automatic travel of the carriage is varied and reversed by means of adjustable stops, and a sliding rod operating a clutch between the reversing pulleys. The grinding head has transverse adjustment on the carriage for feeding the wheel up to its work, the grinding wheel, which is suitably guarded, being mounted on a steel spindle rotating in dust-proof self-lubricating conical bearings. The machine is provided with self-contained driving apparatus, including a two-speed countershaft with long wooden drum from which the emery wheel is driven by a belt, and a three-speed countershaft for causing the work to revolve, besides traversing the sliding carriage. The whole is arranged to be driven by a belt from a constant-speed motor secured on a continuation of the bed-plate of the machine.

The machine shown in Fig. 2 is of the two-spindle planer type, and is specially suitable for locomotive shops for grinding axle-boxes, horn-blocks, slide bars, &c. The bed is 12ft. long, of strong box form, mounted on standards, with wide flat bearing surfaces fitted with automatic lubricating rollers and a tank for collecting the lubricant. The table is 8ft. by 3ft. over the planed part, and has a trough and T-grooves planed out of the solid. It is traversed automatically to and fro up to 8ft. by means of reversing pulleys driven from the main shaft, a steel screw, and gun-metal nut, quick hand adjustment being also provided for setting purposes. The cross slide is adjustable vertically on the uprights up to 2ft. by hand. The two-spindle slides, with spindles 4in. diameter, revolving in hard gun-metal bearings within long counterbalanced sleeves, are adjustable along the cross slide by screws. The spindles have a self-acting reciprocating motion of 9in. vertically, together with means for hand adjustment, and are caused to revolve by means of a horizontal belt and guide pulleys, driven from a pulley on the vertical shaft shown, an adjustable pulley being fitted to regulate the tension on the belt. The two main uprights of rigid box form are firmly keyed and bolted to the sides of the bed, and adjustable stops are fitted to the front of the table to regulate the length of the stroke. The distance from the grinding wheels to the surface of the table is variable from nothing to 2ft. 9in., and that between the spindles is adjustable on the cross slide from 8½in. to 24in.

Another useful appliance for locomotive builders is the link grinding or lapping machine, also made by Hulse and Co., Limited. It is used for lapping out the radius or straight links in valve motion mechanism. It will be seen from Fig. 3 that the headstock, which is bolted to the main frame, carries a vertical counter-balanced spindle, to which combined rotary and reciprocating motions are imparted. To ensure steadiness the spindle carrying the emery grinding roll revolves in two bearings, one above and one below the article being operated upon. The quick rotary motion is communicated to the spindle by a belt-driven bevel friction disc, the slow reciprocating motion being obtained through a rotating cam and oscillating lever driven by a pulley on the headstock. The T-grooved table on which the jig is bolted has compound slides, to the transverse slide of which is imparted a horizontal reciprocating motion, actuated by adjustable lever through gearing driven by the pulley on the headstock and simultaneous radial motion by a connecting-rod and fulcrum, the latter being adjustable along the projecting arm by a screw to suit different radii. There are two sets of driving apparatus arranged to drive by belt from a constant speed motor, the whole being self-contained with the machine.

The machine by H. W. Ward and Co., Limited, illustrated by Fig. 4, is intended for commercial plain grinding. It will take work up to 42in. long by 8in. diameter, and will grind taper up to 14 deg., or 3in. per foot. It is of the type having a fixed wheel and movable slide carrying the work. The wheel headstock is a solid casting, fitted with self-oiling taper, adjustable gun-metal bearings for the wheel spindle. The wheel itself is covered by a substantial cast iron hood, and is fitted with a large water jet. The live spindle in the work headstock is fitted with a toothed wheel, driven by a pinion on a cone shaft carried in the headstock itself. The cone has three steps, from which a belt rises to the long wooden driving drum on the countershaft above. In order to maintain the tension of the belt when the speed is changed from step to step the bearings for the cone spindle can be swung through a considerable vertical angle, the gearing permitting this as the pinion has a planetary motion round the wheel. There are three changes of speed in the countershaft, so that, in all, the work spindle has nine changes. The loose headstock has a spring barrel to accommodate for expansion of the work due to heating. The sliding table is in two parts, an upper and a lower. The latter slides on the fixed bed, whilst the former is pivoted to it near the centre to permit of taper work being ground. It is swung over by a screw finely adjusted by the knurled head seen on the right; a divided collar on this knob permits of fine adjustment. The gearing provides for twelve changes in rate of traverse, and the reverse is effected automatically at each end. The changes are brought about by two of the levers seen on the apron, to the drawing of which—Fig. 6—we now direct attention. By rotating a lever on the shaft A by means of the lever seen in Fig. 4, the fork B is moved along, and the belt moved on to one of the steps of the cone C; thus three changes of speed are secured. The cone is keyed to a spindle carrying two wheels of dissimilar sizes meshing with a corresponding pair on the back shaft; between these two is a clutch D operated by another lever—at the bottom of the apron. This gives two other speeds, or six in all, which are doubled by a two-speed drive from the countershaft; thus giving twelve in all. Following the back





Figs. 7 and 8—WARD'S BUSH GRINDING MACHINE—FRONT AND BACK

shaft in the apron it will be seen that it runs through a reversing gear to a worm which, through further reducing gear meshing with a rack, traverses the table. The reversing gear is operated by the vertical lever in the front view, which is struck first by one dog and then by the other, and is fitted with a spring plunger of toggle form, which obliges it to finish its stroke to right or left. The table can also be traversed by the 10in. hand wheel on the left of the apron. The cut is put on by the smaller hand wheel through reducing gear, and an attachment is fitted for effecting it automatically at each end of the traverse. The amount of this automatic feed can be varied between .00025in. and .01in. reduction in diameter of the work per reversal of the table.

The shear of the upper table is such a form that no splash guards are required. It is shown in section in Fig. 5, which also shows an adjustable steady. It will be seen that the headstocks are guided by the inverted vee marked X, and steadied by the lower surfaces Y, whilst the clamping screws pull on Z.

With a countershaft speed of 420 revolutions per minute the wheel speeds are 966, 1210, 1530, and 1940 revolutions per minute and the work headstock speeds 6, 8, 11, 14, 17, 24, 29, 36 and 50 revolutions per minute, whilst the traverse varies between .180in. and 1.61in. per revolution. It will be noticed that the machine is quite self-contained, no spanners or keys being required for its manipulation.

Another very neat machine is the bush grinding machine, illustrated by the drawing, Fig. 9, which H. W. Ward and Co. courteously permit us to reproduce, and by reproductions of photographs showing the back and front views, Figs. 7 and 8. The machine is intended for doing all kinds of small internal work, such as parallel or taper bushes, up to 6in. long by 6in. diameter, ball races, holes in milling cutters, internal gauges, and so on. It is quite self-contained. The general arrangement—Fig. 9—shows nearly all the principal parts.

Take first the grinding-wheel drive. On account of its small size the stone has to revolve at no less than 12,000 turns per minute. The spindle is carried in a substantial casting locked to the sliding carriage. On the spindle is a very small pulley A, from which a belt is taken to a drum B in the body of the machine. To the shaft of this drum is keyed the small pulley C, which is belted to the big wheel D on the countershaft at the back. The drum is carried in a hinged frame adjustable by screws to keep the right tension on the belt. To prevent the tension coming on the wheel spindle the latter slides through a sleeve, and the sleeve runs in ball bearings. Both the spindle and the tube are independently adjustable in length from the head, so that the spindle may be supported right up to the wheel. The carriage receives its traversing motion from crossed and open belts on the pair of wheels E in the base of the machine and the pair F above. Between the upper two is a clutch moved by the reversing lever. The motion is transmitted through worm gearing, &c., to a rack. The wheels E are now driven by a belt on the countershaft, as shown in Fig. 9, and the speed of traverse is therefore constant. Engravings Figs. 7 and 8 show a slightly different arrangement, under which the traverse varied with the speed of the work spindle, but this has now been given up.

The work headstock is mounted on a slide with cross adjustment to give the feed. This headstock has two spindles geared together—see plan, Fig. 9, One spindle is fixed and carries the belt pulley, the other spindle is carried in a frame hinged on the first, and it can be raised up so that the work may be examined and gauged with ease. This second spindle carries the chuck, either a self-centering three-jaw or a draw-back collet chuck. When down in its place it is firmly locked in position. The work spindle runs in adjustable gun-metal bearings with adjustable ball thrust. The feed motion is effected by a screw and hand wheel divided to read half-thousandths of an inch on the diameter of the work. The headstock can be swivelled through an angle of 45 deg., and the base is graduated for adjustment. The work spindle has six changes of speed, and it is clutched in or out by the treadle shown in Fig. 9.

The whole machine, it will be seen, is self-contained, and all parts are neatly cased in. A copious water supply is drawn by a pump from the base and pumped up to the work. By a modification of the same design the machine is made suitable also for face grinding.

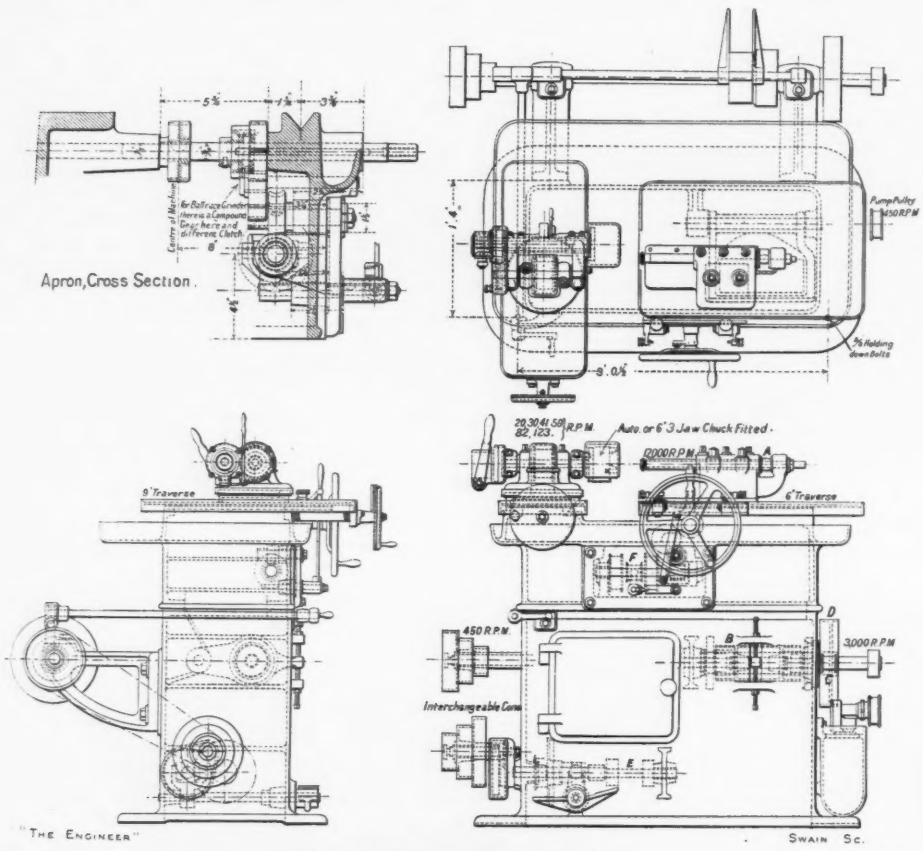


Fig. 9—WARD'S BUSH GRINDING MACHINE

Fig. 10 represents a machine made by Geo. Richards and Co., Limited, Broadheath, near Manchester, and in use by many of the leading railway companies. It is used for grinding locomotive engine piston and valve-rods, but is capable of treating all kinds of parallel cylindrical work within its capacity. The machine is made in two sizes to grind work up to 6in. diameter and 5ft. 3in. long and 12in. diameter and 8ft. 3in. long respectively. The work is mounted in dead centres and is driven at a slow speed by a pulley which carries driving pins. This pulley is driven from a countershaft separate from that which drives the grinding head, but receives its motion from the main countershaft, cone pulleys being provided for varying the speed according to the diameter or nature of the work being operated upon. The centres carrying the work are adjustable to any position on the bed, so that varying lengths of work can be dealt with. The head carrying the grinding wheel traverses automatically along the bed, this motion being given by a screw, on the end of which are mounted two pulleys running in opposite directions to each other. A clutch is interposed between these pulleys and is actuated by a rod on which stops are placed. These, by making contact with the traversing head, effect the reversal of the wheel carriage at any desired point. Knife edge levers are used in this mechanism to ensure reversal taking place at exactly the same place each time.

The wheel head is guided by means of a cylindrical guide of large diameter, this form being considered the best for the purpose, and an auxiliary slide formed on the bed serves to take the weight of the head. The head has a cross traverse by screw to accommodate different diameters of work, and on this screw is fixed a worm wheel. The worm engaging with it has a dial, thus providing micrometer adjustment for putting on the feed. The machine can be arranged if desired for the feed to be put on automatically at each reversal. The grinding wheel is 10in. diameter and 1¼in. wide. A trough is provided in front of the machine for catching the water which is pumped upon the work as the grinding proceeds. The water is returned to the main frame of the machine—which forms a tank—at the extreme end to that at which the pump is fixed; thus as the water in its course passes through small holes in the webs of the tank, it is delivered to the pump free from grit or other objectionable matter.

A locomotive wheel crank pin grinding machine by Beyer, Peacock and Co., Ltd., is illustrated in Fig. 11. This machine is really a new design of an old model, and the grinding wheel is made to rotate round the crank pin according to the method originally devised by Mr. H. Pearse, chief mechanical engineer of the Central Argentine Railway Company. The machine is capable of dealing with crank pins in wheels of various railway gauges and of a maximum of 13in. radius of throw. It stands upon a strong bed, on which are placed two brackets, each capable of being moved along the bed by means of a rack and pinion. These brackets are provided with screws and nuts for raising the wheels and axle to the desired height, and cramps for securing the axle, and pins for locking the wheels securely in position. The casting on the left hand carries a headstock, which can be moved backwards and forwards on a slide by means of a screw. A reversing motion is provided, and can be actuated automatically by means of an improved tappet arrangement. This motion can be instantly started, stopped, or reversed by hand by means of the lever shown. The spindle upon which the grinding wheel is mounted is of tool steel, and runs in gun-metal parallel bearings. In addition to revolving on its axis, it has a variable excentric motion derived from a system of excentric sleeves, which are revolved by worm and worm wheel, mitre gear, and belt pulley. On the opposite end of the bed is provided a bracket or stay capable of being moved along the bed by a rack and pinion, and having a slide which can be raised or lowered by hand. This is provided with brackets having adjustable centres for fixing the exact position of the axle centre, and for testing the centre of crank pins for right and left-hand cranks. The machine is provided with a pump and water service, and with efficient guards and troughs for protecting the slides and conducting the water back to the tank.

The same makers have lately placed on the market an improved form of their Universal type of lapping and grinding machine for locomotive and other case-hardened work. As will be observed from a study of Fig. 12, the machine now consists essentially of a box body, forming a cupboard for tools, and also containing the tank for the lubricant. The slide for supporting the table has one V and one flat shear, with oil pockets and rollers, and also contains the gearing for operating the table. Motion is derived from worm gearing working in an oil bath, and operated from the driving shaft placed at the back of the machine. The mechanism for reversing the motion of

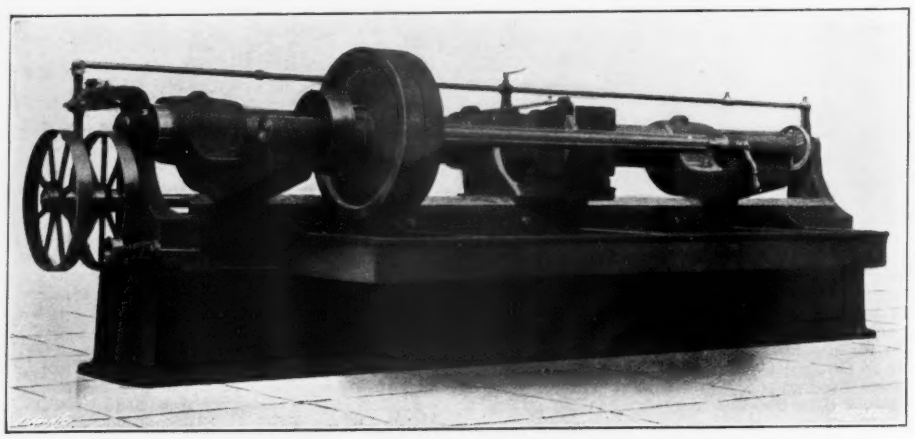


Fig. 10—RICHARD'S PISTON-ROD GRINDING MACHINE

the table has been re-designed, and provides a very sensitive arrangement to enable the reversal to take place with accuracy when grinding links. The table can also be started, stopped, or reversed instantly by the movement of a lever in front of the machine, and a hand wheel is provided for moving the table along the slide. A smaller hand wheel and worm gear allow of finer adjustments to be made when lapping out holes. The auxiliary table used for grinding engine expansion links has now a motion of sufficient length to grind up to 21in., the desired radius in the case of radial links being given by a rod or bar fitted to a swivel bracket at the back of the machine.

When grinding radial links the supplementary table is reciprocated by a stud and die secured to the main table, and working in connection with a transverse slide in the supplementary table; but when engaged in grinding straight links the radius bar is disconnected and the supplementary table is secured to the main table by clips.

The grinding head is fitted with a multiple excentric spindle, whereby the grinding spindle, in addition to revolving on its own axis, also revolves in axes of varying excentricity, which can be adjusted by hand to suit various diameters of holes to be lapped. The grinding spindle is carried in ball bearings, and can be caused to revolve at six different high speeds so as to enable wheels of various diameters to be used at their correct cutting speed. A centrifugal pump and efficient water service are provided, the water being conveyed back to a tank in the bed.

A taper hole grinding machine which is being placed on the market by Beyer, Peacock and Co., Limited, Manchester, has been designed to meet the difficulties experienced when using lead or other laps for truing taper or conical holes in locomotive and other kinds of work, and when the shape of the work precludes it from being revolved. The construction of the machine will be understood from the drawing—Fig. 13—which represents end and side elevations. A main body A supports a horizontal cylinder or drum B, revolved at a constant speed by means of the worm and worm wheel C. In the interior of the drum is a carriage or cross slide D, which is capable of being traversed across the drum by means of the hand wheel E and gearing. The carriage supports a hollow shell F, pivoted at the front end of the revolving drum, and capable of being locked at any angle up to the maximum by means of the quadrant and locking screws G. Sliding in the shell F is a second shell or spindle H, which receives a reciprocating movement by means of the rocking lever J. In the spindle H is the fast running grinding spindle K, which is driven by a belt from an overhead countershaft. The rocking lever J derives its motion from the main shaft of the machine through gearing and the worm wheel and hand wheel L. The latter is provided with a clutch to enable either hand or power traverse to be used. The work to be ground is supported on a compound table M, which can be adjusted in any direction. It will be seen, therefore, that the construction of the machine is such that the grinding wheel is traversed parallel to the side of the hole being ground—such surface being at the angle for which the spindle is set—and at the same time is revolved round the axis of the hole. The maximum incline that can be ground in the machine illustrated is 1 in 8 per side—making a taper of 1 in 4—down to a parallel hole. The main driving shaft at the side of the machine is fitted with fast and loose pulleys and belt shifting gear, while a fast-running pump at the back provides for a continuous supply of water to the grinding wheel, the drainage being conducted back to a tank in the bed. It will be observed that all the levers are conveniently arranged on the working side of the machine within easy reach of the operator.

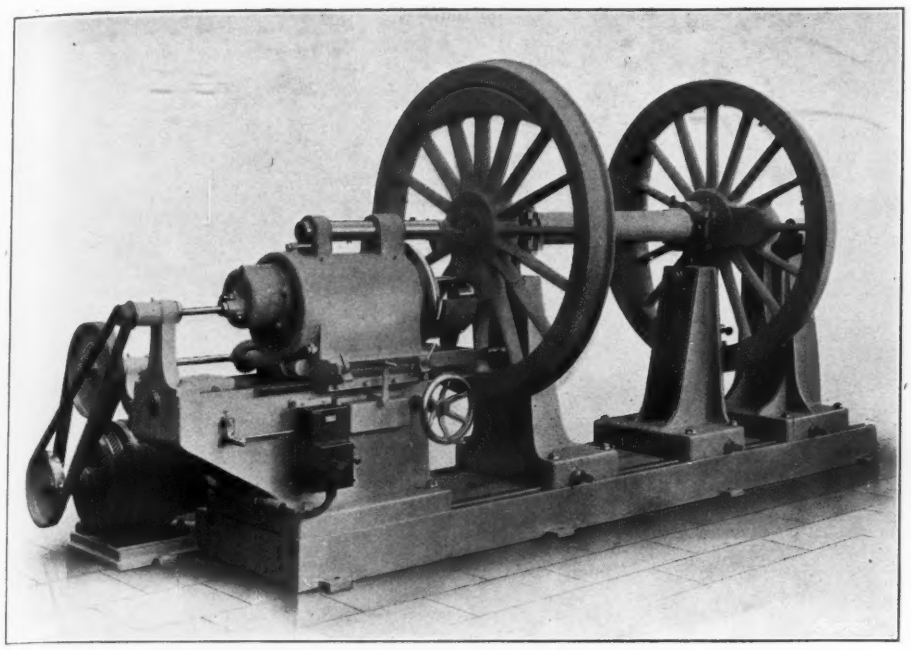


Fig. 11—BEYER, PEACOCK AND CO.'S CRANK PIN GRINDING MACHINE

The ordinary grinder made by the Norton Machine Tool Company, of Worcester, Mass., for whom Ludwig Loewe and Co., of Farringdon-road, London, are the agents in this country, of the latest pattern is shown in Fig. 14, and a similar machine fitted up for grinding motor cranks is illustrated by Fig. 15. This attachment is fitted to the standard 14in. by 72in. or 10in. by 50in. sizes of the Norton plain cylindrical grinder shown in Fig. 14, the general utility of which is in no way affected by the attachment. The headstock of the machine is provided with an adjustable centre, whilst the tailstock end is a device by means of which the crank shaft is always located in the machine in relation to a particular shoulder. While the shaft is being thus located the headstock centre is free to adjust itself according to the depth of the centre hole or the overall length of the shaft. The crank shaft duly in position, the headstock centre is clamped and the tailstock brought up to the opposite centre. On the front of the table of the machine somewhat to the left will be noticed a slotted bar, and on the base a bracket and pin which engages the slots; the latter are arranged in relation to the shoulders on the shafts to be ground. The table of the machine is thus located for each separate bearing. The forgings are rough ground on journals and pins to within .03 to .035 of the finished diameter, during which operation the fillets are also formed. After roughing, the shaft is straightened, say, to within .005in., and then ground to the finished sizes in a similar manner, the edges of the wheel having previously been shaped according to the correct radius of the fillets by means of a radial truing device.

We have selected as a good typical example of the Norton cylindrical grinder an 18in. by 96in. machine, which embraces all the features characteristic of this make. As in all Norton machines the wheel is fixed, the spindle being carried in a heavy casting, so that vibration may be prevented—a very important matter. The work is carried between dead centres, and in the machine illustrated by Fig. 14 it may be 8ft. long, and anything in diameter from ¼in. up to 18in. The table is compound, the upper portion being pivoted to permit of taper work being done; the maximum taper available is 2in. per foot. Both the table and the work have a long range of speed variation, independent of each other, and obtained, in both cases, by a simple belt-shifting device. All the changes are effected from the front of the machine, and there are no cones on the overhead motion. In both these speed gears one member is a plain drum and the other a stepped cone, a jockey pulley or its equivalent being used to maintain the tension. The machines have also automatic cross feed actuated by a ratchet and pawl, the mechanism of which will be understood by an inspection of the engraving. Six universal steady rests are provided. The wheel has three speeds, and it is usually 24in. diameter by 2in. face.

An interesting example of a grinding machine designed for one special purpose is afforded by the machine for grinding the tires of rail and tramway wheels, illustrated by Fig. 17, also constructed by the Norton Grinding Machine Co., of Worcester, Massachusetts. The machine was originally designed to deal only with the wheels of passenger coaches, as, on account of the absolute smoothness and circularity of the work turned out, very easy and quiet running is obtained; but we are informed that it has proved so beneficial in the prevention of flats and high places on wagon wheels that it is also being used for them. As shown, it is only suitable for 4ft. 8½in. gauge, and cannot be used for any other size. The arrangement is fairly obvious from the illustration, but the two dead centres between which the axle is carried cannot be seen. The central belt on the four step cone drives the wheels through the medium of the worm and wheel, whilst the wheels of large diameter are driven direct by belts from the countershaft; another belt drives the self-acting traversing motion, which carries the stone to and fro across the face of the work. This gear can be thrown out of operation at either end by turning a small handle. The feed is put on by hand, and is not automatic. In order to permit the axle to be put into position in the drive bearing a segment of the worm wheel is removable, and in order that the operation of taking out a wheel may be performed with ease an arrangement is provided for stopping the revolution at the right place. This machine will grind carriage wheels up to 44in. diameter, and engine bogie wheels up to 36in. diameter, with an accuracy within .002in. or .003in. From twenty to twenty-five pairs should be turned out per day of ten hours.

A large plain grinding machine for heavy work which has recently been built by G. Birch and Co., Salford, Manchester, is illustrated in Figs. 16 and 18. The first figure shows the machine equipped for external grinding, while the line drawings—Fig. 18—show the internal grinding fixture in position on the front of the

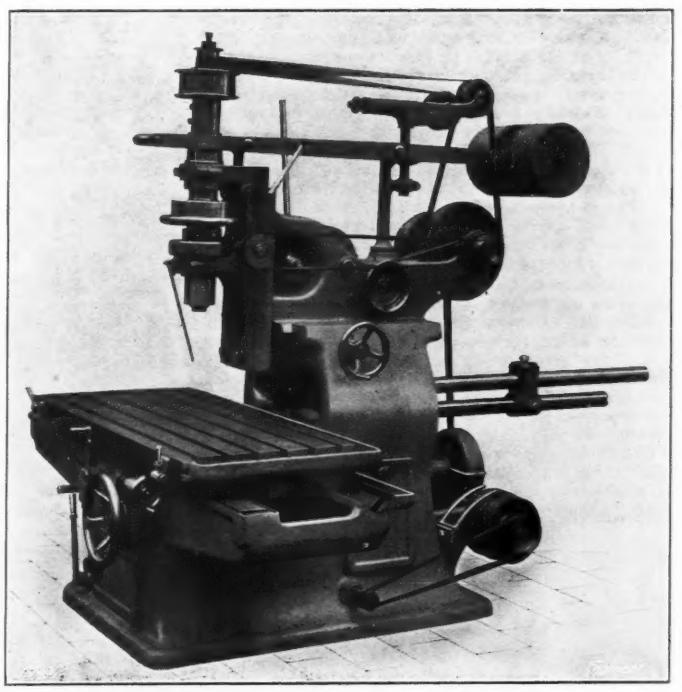


Fig. 12—BEYER, PEACOCK AND CO.'S UNIVERSAL LAPPING AND GRINDING MACHINE

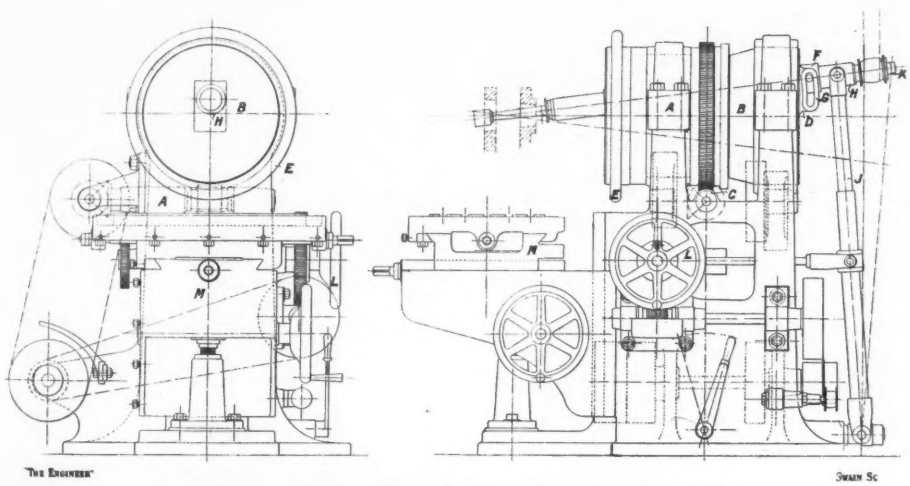


Fig. 13—BEYER, PEACOCK AND CO.'S TAPER HOLE GRINDING MACHINE

wheel head. The drawings also show the details of the apparatus and construction of the machine itself, sectional views being given of the work headstock with its large hollow spindle, and of the emery spindle for external grinding, showing the large double cone bearings, with oil wells and ring lubricating arrangement. The machine is known as the "No. 17" size, and admits work up to 18in. diameter and 7ft. 6in. long. The bed is 14ft. long over the slides, and has an extension at the rear on which is mounted the emery head, and there is a tray for catching the spray from the wheel. The work headstock is arranged with a running spindle for internal work, &c., the spindle having a hole $3\frac{3}{8}$in. bore throughout, so that long shafts can be accommodated for grinding their ends, thus increasing the capacity of the tool for certain classes of work. The loose headstock has both spring and screw adjustment to the centre, so that either can be used as desired. The T slot in the top table is planed at an angle, so that the headstocks are pulled against the front face, thereby eliminating errors due to the wearing of the slot. For grinding tapers up to $1\frac{3}{4}$in. per foot a swivel table is fitted, and for greater tapers than this the nut of the set over screw can be released by withdrawing a pin, enabling the table to be set by hand as required.

The mechanism for traversing the table of this machine gives eight changes, varying from $\frac{1}{4}$in. to $1\frac{1}{4}$in. per revolution of the work, thus providing a fine feed suitable for internal grinding or a coarse feed equal to the width of the emery wheel for external grinding. The reversing stops for the table traverse are carried on a rack seen in front of the table to facilitate adjustment, and in order to prevent the spaces between the teeth of the rack becoming clogged with dirt, &c., the teeth are placed on the under side. The emery wheel spindle is of hardened steel, running in phosphor bronze bushes, with an oil well and ring lubrication. The spindle carries an abrasive wheel, 18in. diameter by $1\frac{1}{2}$in. wide, and is driven by a three-speed cone pulley, which allows the surface speed of the wheel to be correctly maintained as the wheel becomes worn. The automatic feed motion will give any feed to the grinding wheel from 0.00025in. to 0.004in. at each reverse of the table, and the feed is independently variable at each end of the table, so that, if required, the feed can be put on at one end of the work only.

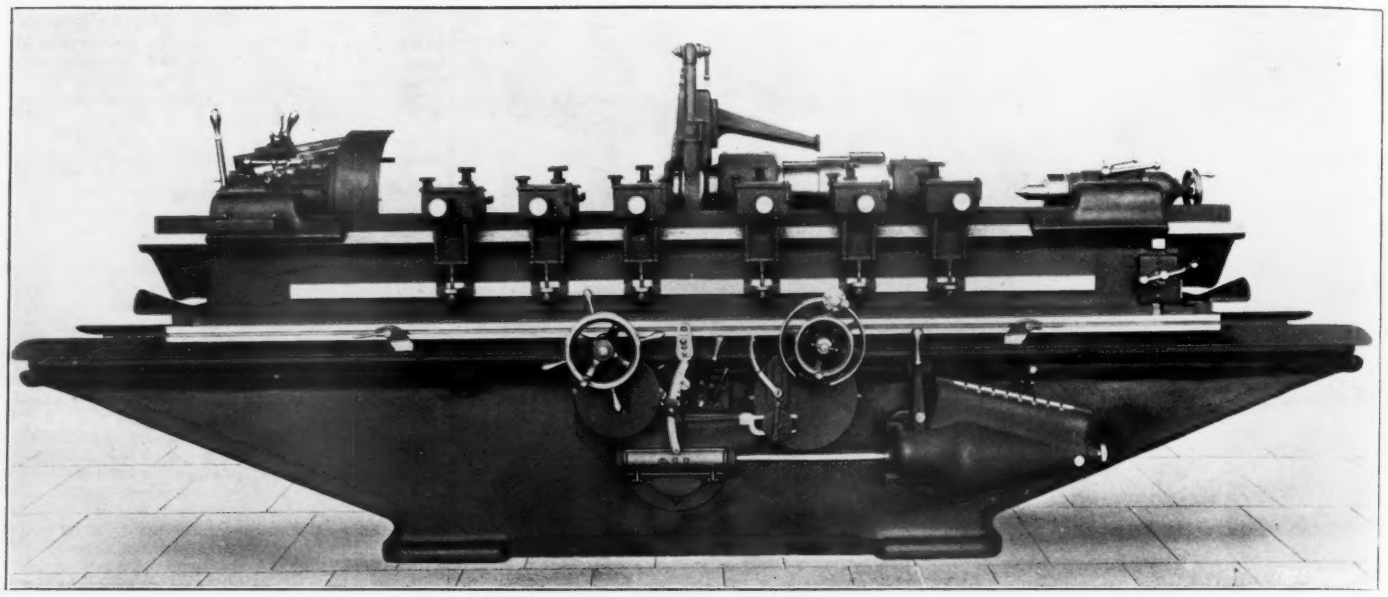


Fig. 14—NORTON PLAIN GRINDER

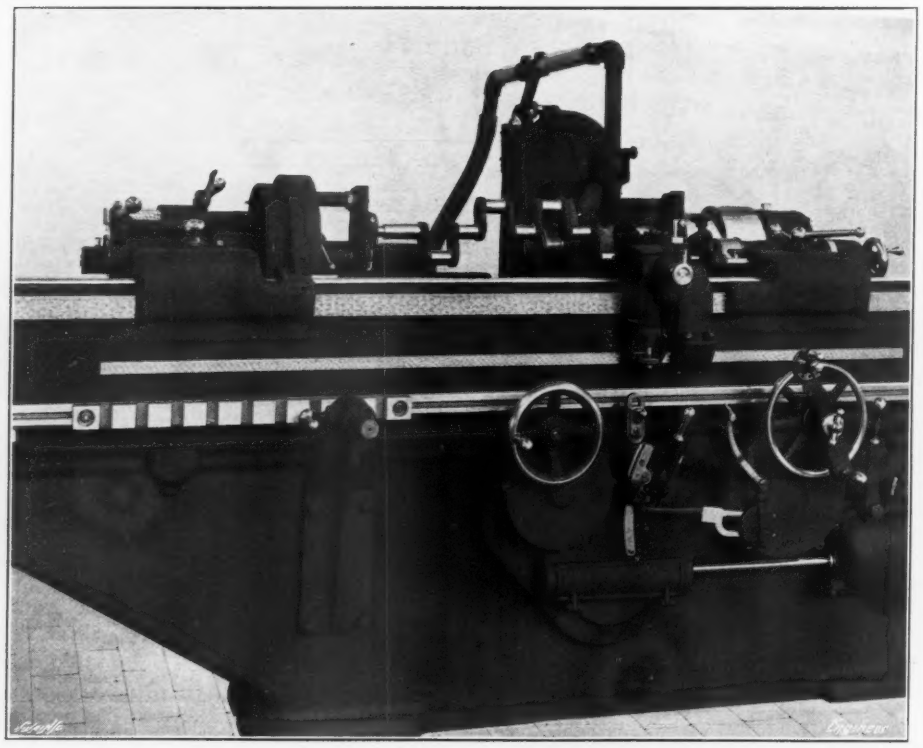


Fig. 15—NORTON GRINDER WITH CRANK SHAFT ATTACHMENT

The internal grinding attachment, as shown in Fig. 18 is bolted on to the front of the grinding head, the wheel flanges being removed for this purpose. The attachment is driven by a countershaft fastened at the rear end of the wheel slide, the countershaft having a cone pulley, which is a duplicate of that on the wheel spindle, with a large diameter pulley for driving on to the pulley of the spindle—see plan. The countershaft is arranged to slide on the headstock, so that the belt can be tightened readily. This attachment is intended to grind holes from 3in. diameter and up to 12in. deep, and will carry a grinding wheel up to 3in. diameter and $\frac{1}{4}$in. wide. The spindle is hardened, and runs in phosphor bronze bushes. The attachment is easily fixed or removed.

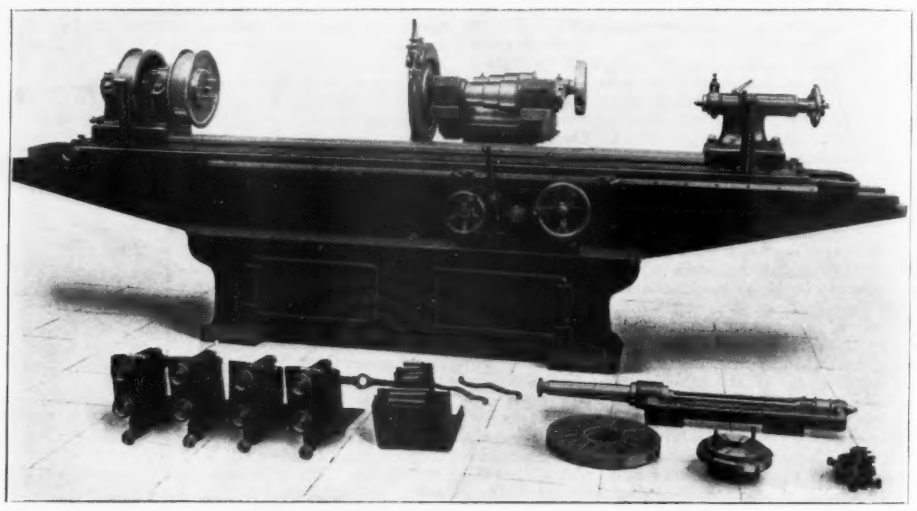


Fig. 16—BIRCH AND CO.'S PLAIN GRINDING MACHINE

Fig. 19 represents one of the smaller sizes of universal grinding machines made by G. Birch and Co. Recently these machines have been improved and brought up to date to enable heavier cuts to be taken. The grinding wheel spindle has been stiffened, and the design of the back rests has undergone alteration. These rests have two jaws swinging on a hinge joint, and are independently set up by screws, one jaw supporting the work below and the other behind. Both jaws are fitted with removable brass steps to suit the work. The stops for reversing the motion of the table are fitted to a small rack in front of the table, giving instant adjustment, and the teeth are placed below to prevent the spaces being choked with dirt. The automatic feed for the emery wheel is stronger than formerly; the ratchet wheel having coarser teeth than usual, the wear is minimised, while the feed is increased. Any amount of feed can be obtained from .00025in. to 0.003in. at each reverse of the table, the feed being capable of independent variation at each end of the table, so that the feed can operate at one end of the traverse only if so desired.

John Hetherington and Sons, Limited, Manchester, build a grinding machine specially intended for treating the surface of carding engine cylinders, drums, pulleys, &c. A general view of it is given in Fig. 21. The base-plate is one casting, planed on the top face, and having ⊥ slots cut out of the solid to receive two end standards and two intermediate standards. The end standards are planed on the top and bottom surfaces, and securely bolted to the base-plate. The intermediate standards are also planed on both surfaces and bolted to the base-plate, but the right-hand one is adjustable longitudinally by means of a capstan head, pinion and rack to

suit different lengths of cylinders. These intermediate standards are provided with adjustable capped bearings for receiving the revolving mandril on which the article

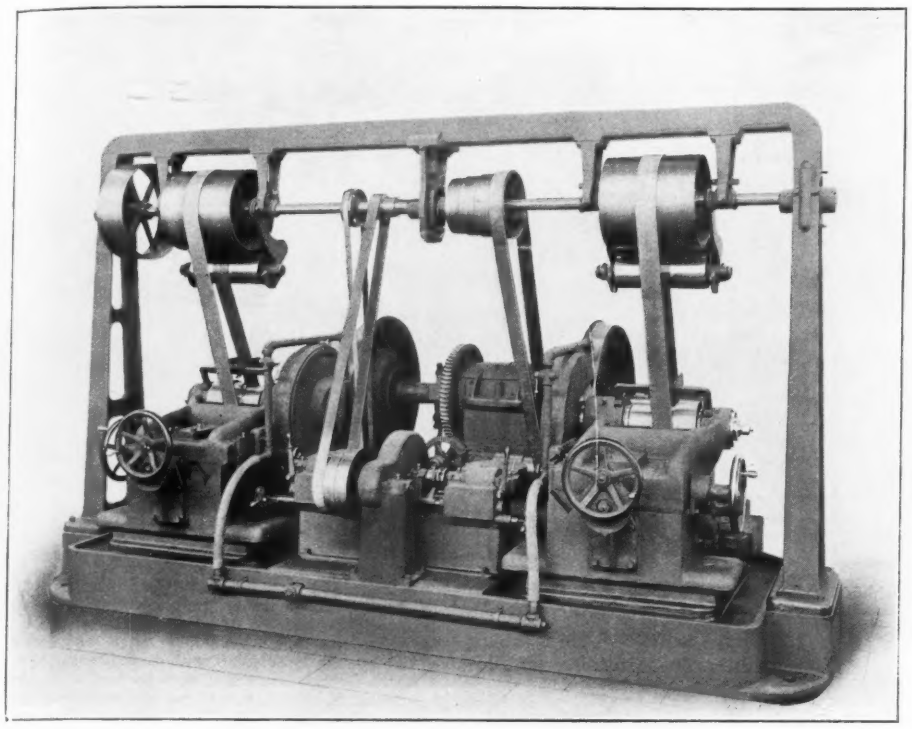


Fig. 17—NORTON RAILWAY WHEEL GRINDING MACHINE

to be ground is mounted. The longitudinal slide bed is of the box pattern, having a series of box bars and wide top V's machined on the top and bottom faces. It is slide is accurately machined and fitted to the bed with adjustable V strip to take up the wear, and the upper face is provided with transverse V's for receiving the grinding spindle head. The latter is made adjustable by means of a hand wheel, square-threaded screw and gun-metal nut for regulating the cut of the emery wheel.

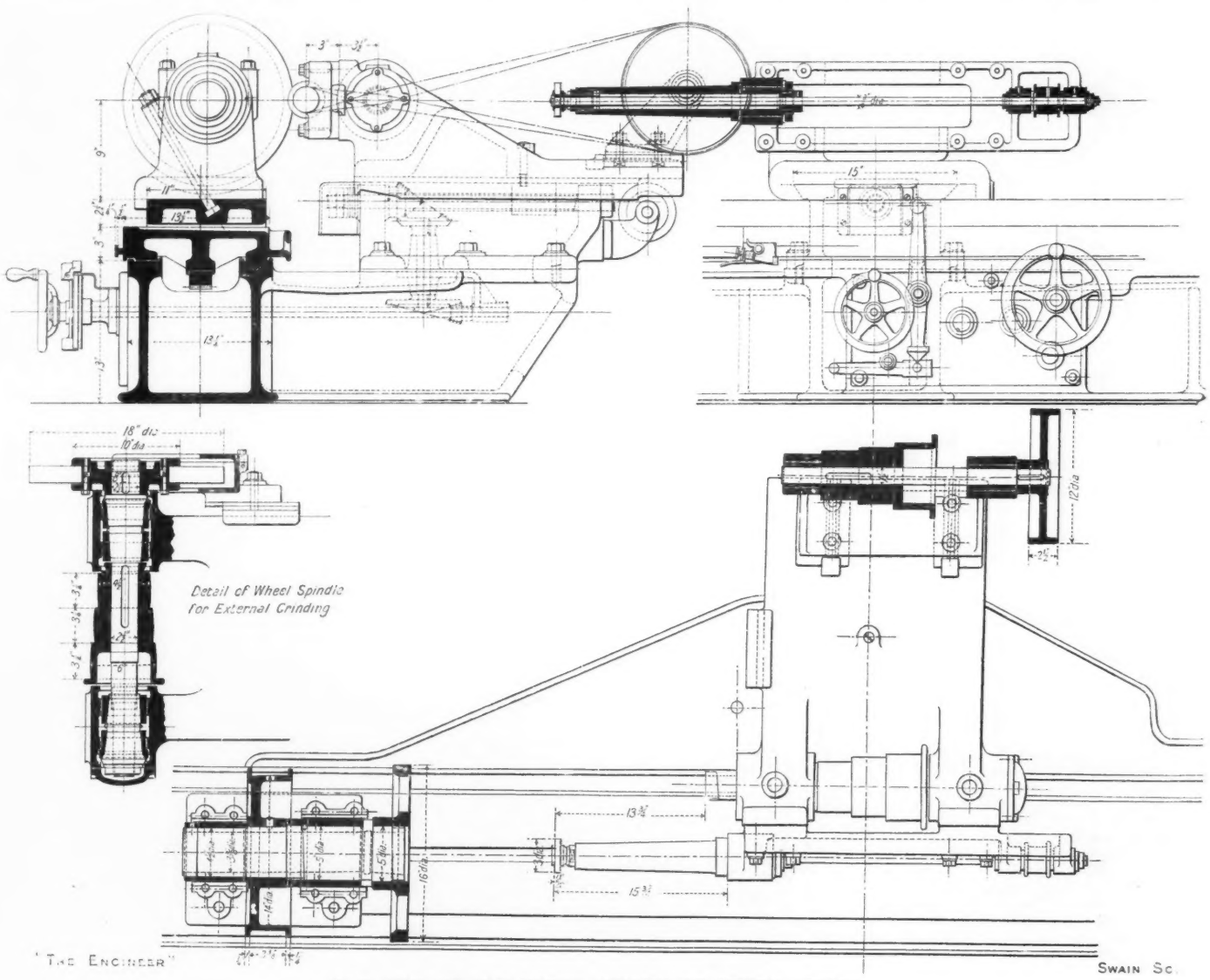


Fig. 18—BIRCH AND CO.'S MACHINE ARRANGED FOR INTERNAL GRINDING

secured on the four standards, and is fitted with a traversing slide, which is of unusual length to protect the wearing surface from the emery dust. The traversing

The steel spindle is 2¼in. diameter, revolves in long adjustable gun-metal bearings, and is fitted with a double-flanged pulley. The grinding wheel is 14in. diameter by 1in. wide, and its peripheral speed is 2200ft. per minute. The driving of the traversing slide is effected by means of a double-flanged pulley, mitre wheels, square-threaded screw, and gun-metal nut. To regulate the length of the stroke adjustable stops are provided, and there is also an automatic reverse motion. The machine will grind articles from 1ft. to 4ft. 3in. diameter.

The automatic flat grinding machine, with two spindles, shown in Fig. 22, is made by Kendall and Gent, Limited, Manchester. The bed has planed and surfaced slides, forming a tank for the water, and rests on the foundation the whole length. The table has a trough and T slots planed from the solid, and is moved by rack and pinion, spur gearing and pulleys on flat slides; it is provided with self-acting reversing motion, as well as adjustable stops for regulating the length of traverse. The heavy uprights with vertical slides are rigidly fixed to the bed, and the saddles are counterbalanced, having an independent vertical adjustment by screw and hand-wheel to compensate for varying diameters of emery wheels and depth of work. The spindles carrying the emery wheels are of hard steel, and revolve in long parallel gun-metal bearings adjustable for wear. Each spindle is provided with independent driving and adjustable self-acting reciprocating motion for varying widths. The countershaft is carried in bearings formed on brackets cast with uprights, thus rendering the machine entirely self-contained. To maintain the tension on the belts when elevating or lowering the saddles jockey pulleys are provided. The emery wheels are 15in. diameter by 3¼in. wide. The dimensions of the machine are as follows:—Length of bed, 15ft.; to grind in length, 9ft. 6in.; width between uprights, 3ft. 5in.; width of table inside trough, 3ft.; self-acting reciprocating motion, from 0in. to 1ft.; distance from centre of spindle to table, minimum, 1ft.; maximum, 2ft.

The same makers are responsible for the machine Fig. 20, which is designed for the rapid internal grinding of all kinds of cylindrical hollow work, having parallel or conical holes, whilst it is also capable of grinding on the face without re-setting. The machine is substantially built, so as to be free from all jar or tremor when working, and consists of a bed of heavy design having accurately planed and surfaced vee slides for the wheel carriage, and also a planed and surfaced slide at right angles for the headstock carrying the work. The centre portion of the bed forms a cabinet for tools. The headstock has a strong steel spindle with hardened and ground conical necks running in phosphor bronze bearings, adjustable for wear and fitted with a self-centering chuck for carrying the work. The headstock is mounted on a slide on the bed and arranged to swivel, so as to enable conical holes to be ground. A stop is

provided for setting dead true when grinding parallel holes. The screw for traversing the headstock on its slide is provided with coarse and fine adjustment, the latter being graduated to $\frac{1}{1000}$in. As will be seen, the spindle and chuck are rotated by means of an electric motor, though provision can be made for driving from overhead by means of belting when desired. The carriage carrying the grinding headstock is provided with means for fixing and driving three high-speed internal grinding spindles, which are suitable for varying diameters of emery wheels. By means of these wheels holes can be ground from $\frac{3}{4}$in. diameter upwards. The carriage is provided with automatic reciprocating motion, five speeds being provided, the length of traverse being regulated by stops, which can be quickly thrown out of gear. A compound slide mounted on ways formed on the carriage at right angles to its length carries a second emery wheel spindle for face grinding, reciprocating being by hand ratchet lever in front of the machine. A fine hand adjustment and stop are provided for putting on the cut, and is graduated to $\frac{1}{1000}$in.; the stop can be quickly thrown out of gear, leaving the wheel slide under hand control. The maximum diameter admitted is 12in.; the maximum length ground from $\frac{3}{4}$in. to 1$\frac{1}{4}$in. inside diameter, 4in.; maximum length ground from 1$\frac{1}{4}$in. to 2$\frac{1}{4}$in. inside diameter, 8in; maximum length ground above 2$\frac{1}{4}$in. outside diameter, 11$\frac{1}{4}$in.; the traverse of table, 15$\frac{1}{2}$in.; and the traverse of the headstock, 20in.

The piston-rod grinding machine—Fig. 23—by James Archdale and Co., is of a very simple design. The wheel is driven direct from a long drum on the countershaft above, and it traverses automatically up and down the work, the reverse being effected by the tappet-rod at the back, the lever, and the clutch between the open and crossed belt. The speed of traverse is constant, but there are four changes of speed of rotation apart from countershaft changes. The cut is adjusted by a hand wheel raised well over the work as shown. A bracket for holding the trueing diamond is attached to the loose headstock. The machine is finished throughout with the accuracy required in this class of tool. It will take work 8ft. long by 6in. diameter, but a piston 28in. diameter can be admitted at the headstock end. The wheel is 16in. diameter by 1$\frac{1}{2}$in. face. The machine is fitted with removable steadies, of which three are shown in place, but as a rule six are employed.

A special grinding machine of more than ordinary interest is that illustrated by Fig. 24, and made also by James Archdale and Co., Limited. It is designed for grinding the ends of steel shell, and the plan on which it works will be understood readily from the engraving. The reason why projectiles need grinding at all is instructive. It occasionally happens that the points of hard steel shell split spontaneously, due to the internal strains set up by hardening, and it was believed at one time that initial cracks existed in the surface. This fine grinding machine was therefore got out to give the ogival head such a polish that if any cracks existed they could be discovered. We are not sure if the method still continues in use, but several machines have certainly been made. In that illustrated projectiles from 10in. to 13.5in. diameter may be ground. They are held in a headstock fitted with a hollow steel spindle having bearings adjustable and protected from grit and dirt.

This spindle is provided with a self-centering chuck, actuated by a worm wheel and worm, the worm, after tightening the chuck, being arranged to swing clear by an excentric movement. The rear end of the spindle carries an arrangement by which the projectile can be drawn into position for chucking or ejected when desired. This consists simply of a rod which screws into the base of the projectile and is drawn to the rear by rack and pinion.

Arrangements of a familiar kind are, it will be seen, provided for accelerating the speed as the emery wheel approaches the point of the projectile. The special link belt used is automatically traversed from end to end of the coned drums at the same time as the emery wheel traverses from the chuck towards the point of the projectile, by means of gearing, lever and adjustable link work driven from the feed shaft at the back of the machine. The slide carrying the wheel has a radial movement and a self-acting reversing action, enabling the wheel to describe a radius in either direction. This radial movement is actuated from the feed cone pulley through bevel gears, worm and worm wheel, pinion, and rack at its outer radius. The slides are well supported in every position without overhang, and the carriage can be traversed by hand. Adjustable stops are provided to regulate the length of the radial movement. The emery wheel is 2ft. 4in. diameter, and is driven by an electric motor mounted on the carriage, and its spindle is hardened and ground and runs in substantial gun-metal bearings, effectually protected from dirt and grit.

The grinding lathe shown in Fig. 25 serves as an indication of the development which has taken place within recent years in this most rudimentary of all the mechanical operations associated with man's progress. This large tool can accommodate shafts up to 30 tons in weight—the maximum length admitted being about 33ft. and the greatest diameter 3ft. The maker of this machine is J. E. Reinecker, of Chemnitz, for whom Messrs. Pfeil and Co., of London, are the agents in this country. A machine of this description was supplied a short time

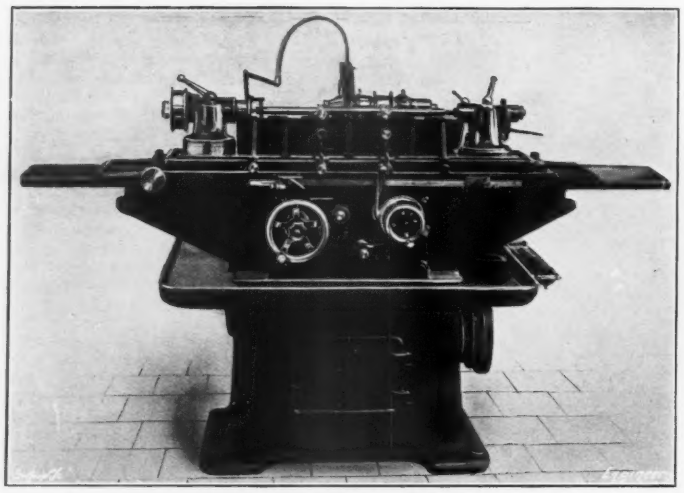


Fig. 19—BIRCH AND CO.'S UNIVERSAL GRINDER

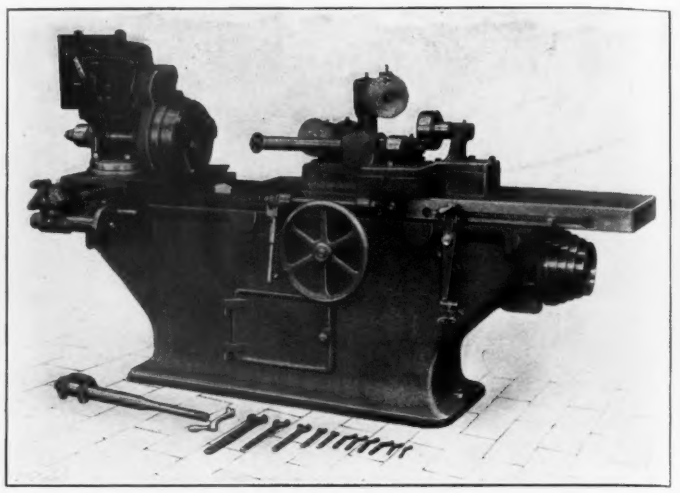


Fig. 20—KENDALL AND GENT'S BUSH AND FACE GRINDER

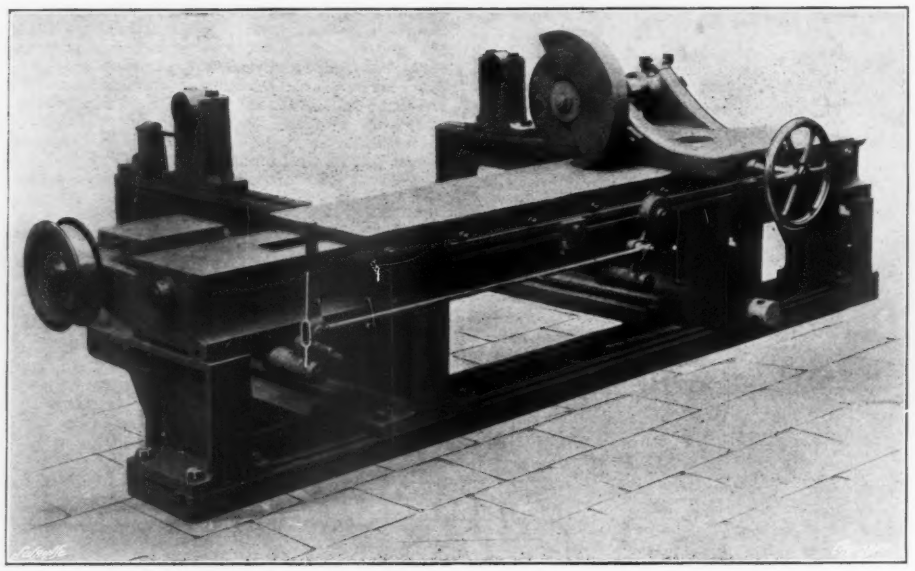


Fig. 21—HETHERINGTON'S GRINDING MACHINE FOR CARDING ENGINE CYLINDERS

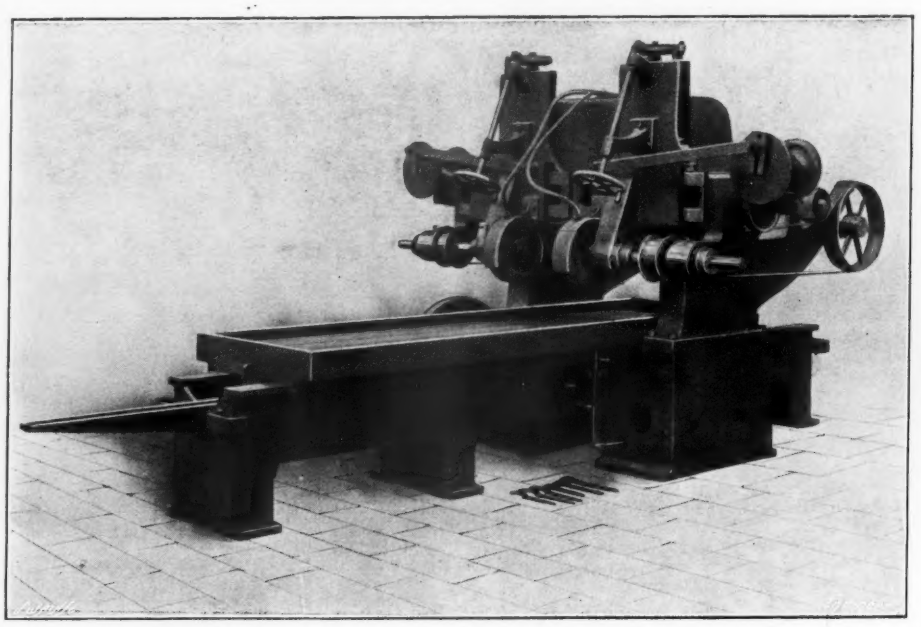


Fig. 22—KENDALL AND GENT'S TWO-SPINDLE FLAT GRINDING MACHINE

ago to Krupps, at Essen, and we understand that another is now in hand for a large firm in Belgium. It will be seen from the engraving Fig. 25 that three independent electric motors—representing a total of 51 horse-power—are employed to drive this machine. The face plate, and along with it the work, is rotated by a work liable to twist when held by the ordinary chucking devices the machine is supplied with an electro-magnetic chuck. The capacity of the machine is sufficient to allow work up to 59in. in diameter and 20in. in height to be taken. A 6 horse-power motor is employed to drive the tool.

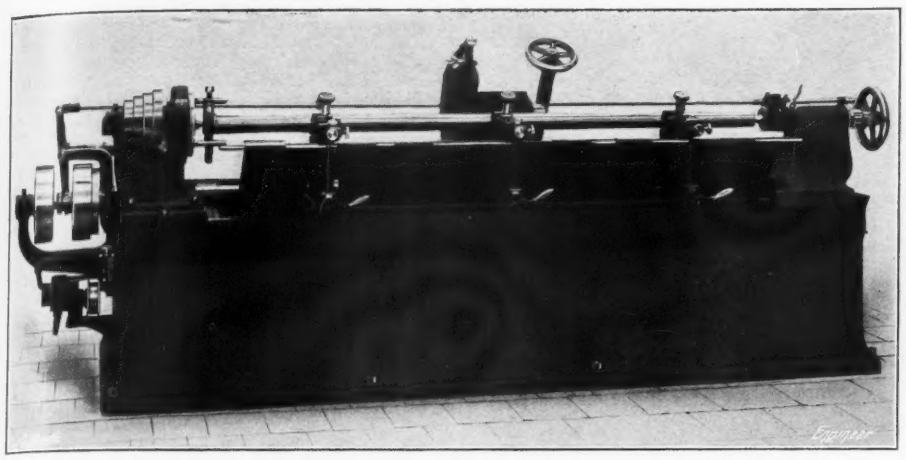


Fig. 23—ARCHDALE'S PISTON-ROD GRINDING MACHINE

16 horse-power motor, which drives through toothed wheels on to the face plate spindle. On the saddle are carried two motors, one of 30 horse-power driving the grinding wheel, and the other of 5 horse-power for traversing the saddle. Other figures relating to this machine are as follows:—Height of centres, 2ft.; length of bed, 46ft.; length over all, 49ft.; approximate weight, 40 tons.

The same maker has several other interesting designs, from among which we have selected those shown in Figs. 26 and 27 for description. In Fig. 26 is shown a large circular-face grinding machine. Two emery wheels are carried on this tool, one to the left of the engraving, with its axis horizontal, the other with its axis vertical but capable of being tilted as shown. Many varieties of work can be undertaken on this machine, and it is especially well adapted for grinding the faces of piston rings and their corresponding grooves. For

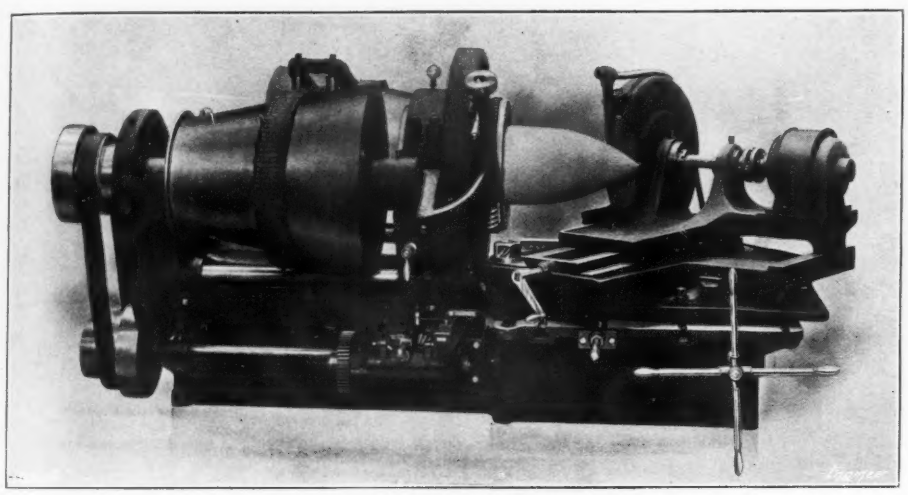


Fig. 24—ARCHDALE'S MACHINE FOR GRINDING SHELL

The tool represented in Fig. 27 is intended for motor work and other light jobs. Two special face plates are employed, each of which carries a socket to receive the ends of the crank shaft. These sockets are adjustable by a screw, and can be set to give the exact throw required by means of a scale and vernier. Balance weights consisting of a number of segment pieces are bolted to the face plates while grinding is in progress.

A very notable machine is the 24in. universal grinder made by Alfred Herbert, Limited, of Coventry, and illustrated by Figs. 30, 31, and 32. It is believed to be the only universal grinder of its capacity at present on the market, and comprises a number of unusual features which have been dictated by the makers' own experience, and which enhance greatly its handiness. The machine takes a 24in. grinding wheel 2½in. wide, and has enough power and sufficiently quick feeds to enable the full capacity of this wheel to be utilised, and it will

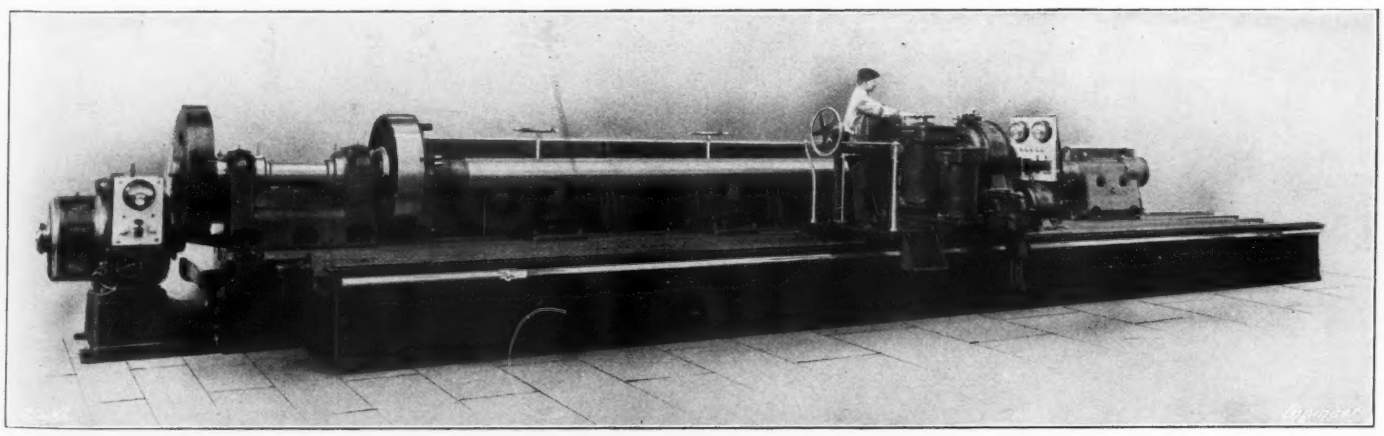


Fig. 25—REINECKER'S MACHINE FOR GRINDING LARGE SHAFTS

take work 10ft. long between centres. It is of the fixed wheel type.

The body of the machine is in one piece, which carries both the grinding wheel head and the tables, as the illustrations show. It is of very strong form, and it is well ribbed and stayed internally. When it was planed it was determined before proceeding further to test it for distortion, and loads were applied in various probable and improbable ways to endeavour to make it change its shape, but without effect. That part of the body on which the grinding wheel head rests is especially rigid, being well trussed to the parts carrying the table; the form, as the size necessitates, being much stronger than the usual T-shaped design which is customary on smaller machines.

The table is supported for nearly the whole of its length when on the longest stroke, and has automatic traverse in both directions, the reverse being controlled by stops which slide in a tee slot on the front of the table, and which can be rapidly adjusted into any position. They have a fine adjustment screw for accurate setting. The automatic reverse lever is so arranged that the table can be traversed past the stops when required, and it will reverse dead to a line when grinding up to a shoulder.

The top table is arranged to swivel for taper work, and

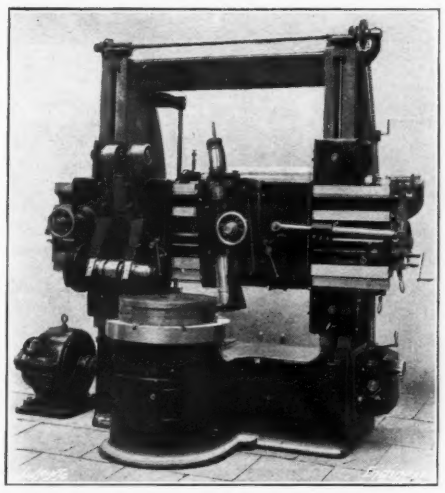


Fig. 26—REINECKER'S CIRCULAR FACE GRINDER

is graduated to read to degrees and inches per foot. It is of particularly strong form—seen well in Fig. 32—and is arranged so as to form natural channels for the water used in grinding to pass away. The number of slots seen in the illustrations aid in this.

The work head can be racked along the table into any required position by a hand wheel and suitable gearing—the rack can be seen in Fig. 32—and can be locked at any part of the bed by a device which not only clamps the head to the table, but also binds the traversing gearing, thus effectually preventing the head from slipping back if any hand pressure is put upon it.

For grinding cylindrical work between centres, the spindle for the work head is clamped so that the centre does not rotate, but outside the spindle centre is a face plate for driving the work and also for carrying whatever chucks may be desired for internal grinding, face grinding, &c. This face plate is driven by spiral gears, the driving shaft being placed at an angle of 45 deg. with the machine. The upper part of the work head swivels round for face or taper grinding, the swivelling movements being graduated. When swivelled through 90 deg. the driving pulley is still at an angle of 45 deg. with the machine, only in the other direction, thus ensuring that the belt is never twisted more than 45 deg. from its medial position. This method of driving is found to be exceedingly smooth, and to produce work free from chatter. When chucks are in use the face plate is clamped to the spindle, which rotates with it. The change is effected almost instantly by a locking pin, an indicating

trigger showing when the wheel and spindle are in the proper relative position. The spindle is of mild steel, case-hardened and ground, and afterwards lapped on the bearing surfaces.

The tailstock is constructed in a similar manner to the headstock so far as regards arrangements for moving it along the table and locking it in position. It is provided with a screw and hand-wheel feed, and also a spring to allow for the expansion of the work.

The steadies, Fig. 28, are of an entirely novel design. The steady blocks are mounted on swivelling arms, the movement of which is controlled by a right and left-hand screw, C D, and the nut in which this screw works is adjustable by a knurled knob F. Thus after the steadies have been set to bear properly on the work by the knob G, they can be moved to and from the wheel as required by the knob F, without altering their position relatively to each other. The action of the steady blocks A and B also holds the work back firmly from the wheel, a feature which is very desirable when grinding work of small diameter. Supplementary steady blocks—see Fig. 29—are provided to bear on the top of the work for the purpose of absorbing vibration. These steadies are clamped to the upper table by a pair of hooks—moved by an excentric motion, and are instantly freed or tightened

The grinding wheel head is a massive casting resting in vee slides, and held down by its own weight, which is great so as to absorb vibration on the anvil principle. This head carries the main grinding spindle, which is very large, and runs in adjustable phosphor bronze bearings, the spindle itself being of steel, hardened, ground, and lapped. The grinding wheel is mounted at the end

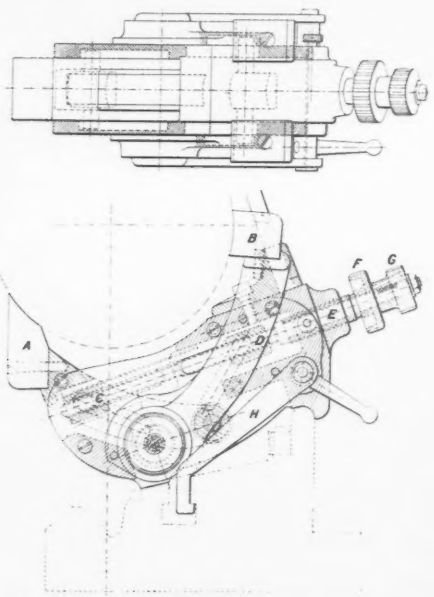


Fig. 28—HERBERT'S STEADY

of the spindle, so that it may be easily changed when desired. The slides on which the grinding head is carried are also very heavy, and rest firmly on their bases by gravity only. The whole of the sliding surface is completely protected from wet and emery dust by means of telescopic sheet steel screens. The wheel head can be revolved by means of a circular rack and pinion, and is graduated in degrees.

The cross feed mechanism for the grinding wheel, besides being automatically operated from the reversing

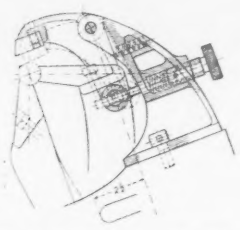


Fig. 29—HERBERT'S TOP STEADY

lever, can also be manipulated by a hand wheel on the front of the machine, and this hand wheel is fitted with six automatic stops, enabling six diameters to be ground accurately on the same shaft. Provision is made for adjusting all the stops together for compensating for the wear of the grinding wheel. This hand wheel can be seen in Fig. 31. The stops are arranged in six circular plates or rings fastened to the hand wheel, and each of these plates has a corresponding knob. Each ring has an internal rack cut in it, and each knob has a pinion with only one tooth, so that one revolution of a knob advances the plate only a very slight amount. A bigger knurled knob advances all the plates simultaneously.

The cross movement of the grinding wheel head is operated

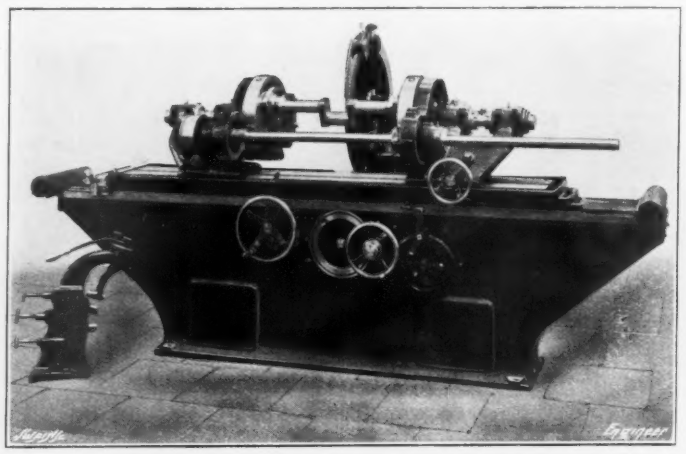


Fig. 27—REINECKER'S CRANK SHAFT GRINDING MACHINE

by rack and pinion, a spring device being incorporated in the slide to enable the operating gearing to act entirely without backlash, the movements of the wheel by this means corresponding closely to the indicators of the index discs. This device enables diameters to be accurately ground and the automatic stop to work within the limit of .00025 of an inch.

Incorporated in the design of the machine are two variable gear motions of the type known as Herbert's patented dial feed, such as are used on the makers' milling machines. Each of these feed boxes gives a range of sixteen variations. One of these boxes is used for driving the overhead shaft from which the work spindle is driven, and the other box varies the feed. The changes are made by two hand wheels at the front of the machine, the ranges of these hand wheels being marked for the various speeds and feeds; all that is necessary, therefore, to change the speed of the work or to change the rate of traverse is simply to turn the proper hand wheel into the correct angular position as shown by the indications upon it. The quickest rate of feed was arranged to act as a quick power motion for setting the machine, but it has been found in practice, and we have found ourselves by trial, that the table moves so easily that it is practically no trouble at all to rack it along by hand.

The feed motion within the bed which operates the table is enclosed in a box which can be entirely removed through a hole in front of the machine, and contains a lubricating pump which keeps all bearings automatically lubricated while the machine is running, requiring no attention whatever from the operator. In addition to this, the gears run in a bath of oil. The countershaft, of which, unfortunately, we are unable to give an illustration, supplies motion to the grinding wheel, which has two speeds; the driving headstock, which has sixteen speeds; the table, which has sixteen rates of feed; and the pump. It can be started and stopped, and the fast and slow speeds given to the grinding wheel head by the movement of a single lever situated in a convenient position for the operator.

The water tanks and the pump are self contained in the body of the machine. There are three settling tanks, supplied with strainers to clarify the water before it is again pumped to the wheel. The water is guided back again to the tank by liberal gutters. The tank is hinged to the bed, and can be canted over for cleaning purposes without the slightest trouble. The pump supplies 30 gallons of water to the work each minute.

It will be noted from the above description that all the mechanism for controlling the work and table speeds is grouped together at one point in front of the machine, within easy reach of the workman, and that all speed changes to the work can be made without stopping either the work or the wheel.

A special safety friction clutch is provided to take any shock when changing the table speed, and the reverse of the table is arranged to give a pause at either end of the stroke to allow for the momentum of the moving parts, and also to give time to grind up the shoulders properly.

The machine, which we have examined very carefully, is a magnificent piece of tool craft, both as respects its design and construction. It has been in use at Alfred Herbert's works now for some months, and has, we are told, reduced the cost of the work which it performs to about half what it was formerly.

The following are the leading dimensions:—

Capacity	24in swing 10ft. between centres
Largest diameter admitted in steadies	12in.
Diameter and width of grinding wheel...	24in. by 2¼in.
Diameter and length of grinding wheel spindle bearings	large bearing 4½in. by 12in. small bearing 3in. by 9in.
Changes of grinding wheel speed ...	4
Automatic cross feed of grinding wheel from least ... ·00025in. to greatest ... ... ·002in.	reduction in diameter of work for each reversal of table
Diameter of headstock spindles ...	4in.
Diameter of tailstock spindles ...	3½in.
Number of changes of work speed	16
Number of changes of table traverse	16
Floor space occupied..	7ft. 10in. by 27ft.
Weight	about 13 tons

A universal cutter and tool-grinding machine manufactured by Alfred Herbert, Limited, of Coventry, is illustrated in Fig. 33. This machine is intended for general tool-room work, and, the makers state, will do almost any variety of circular and surface grinding. The particular

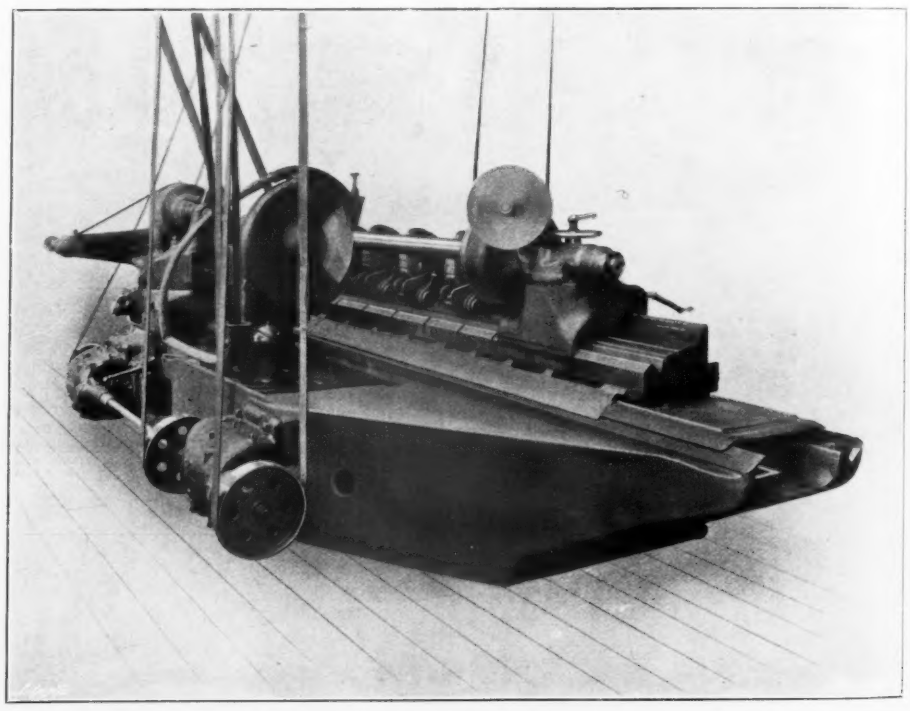


Fig. 30—HERBERT'S LARGE UNIVERSAL GRINDING MACHINE—BACK VIEW

feature which gives its universal character to the machine is a combination of quick and slow movements to the two adjustments of the tables. Thus either the longitudinal or the cross motion may be used for traversing the work across the wheel with a quick feed or for putting on the cut with a fine feed, and so enabling a great variety of work to be ground without special appliances. The grinding spindle of case-hardened mild steel is provided with a standard taper hole at each end to carry the short or long arbors on which the emery wheels are mounted. A two step cone pulley is mounted on the spindle, which runs in hard phosphor bronze dust-proof bearings. The tables are mounted on a knee sliding vertically on a long sleeve, which can be swung round the columns into any position. To alter the height of the tables a hand wheel carried on a shaft, and provided with an adjustable index disc, is provided. The tables themselves consist of a pair of compound slides carrying a third and swivel top table for use when taper work is being ground. This swivel table can be removed, thus permitting the

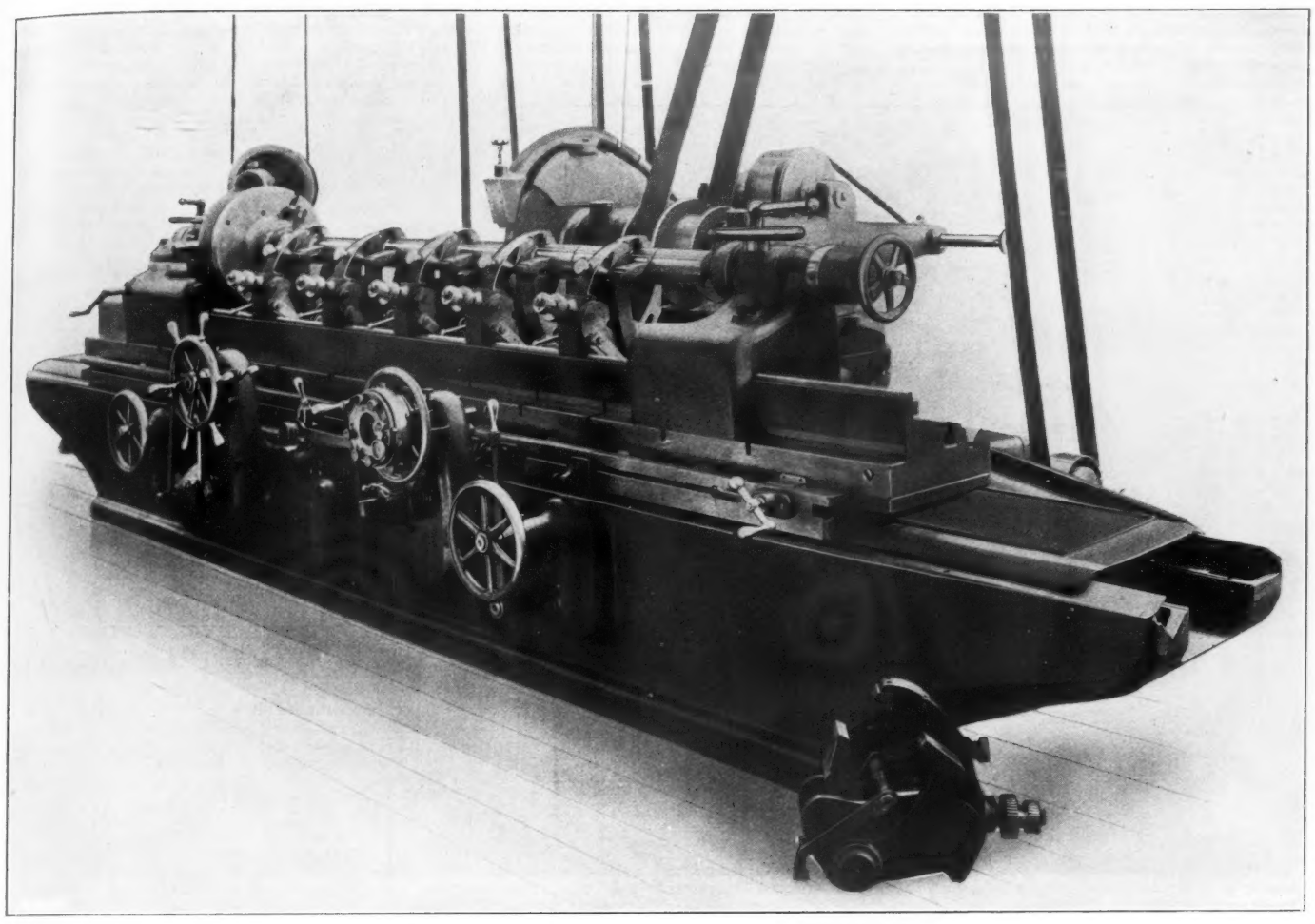


Fig. 31—HERBERT'S LARGE UNIVERSAL GRINDING MACHINE—FRONT

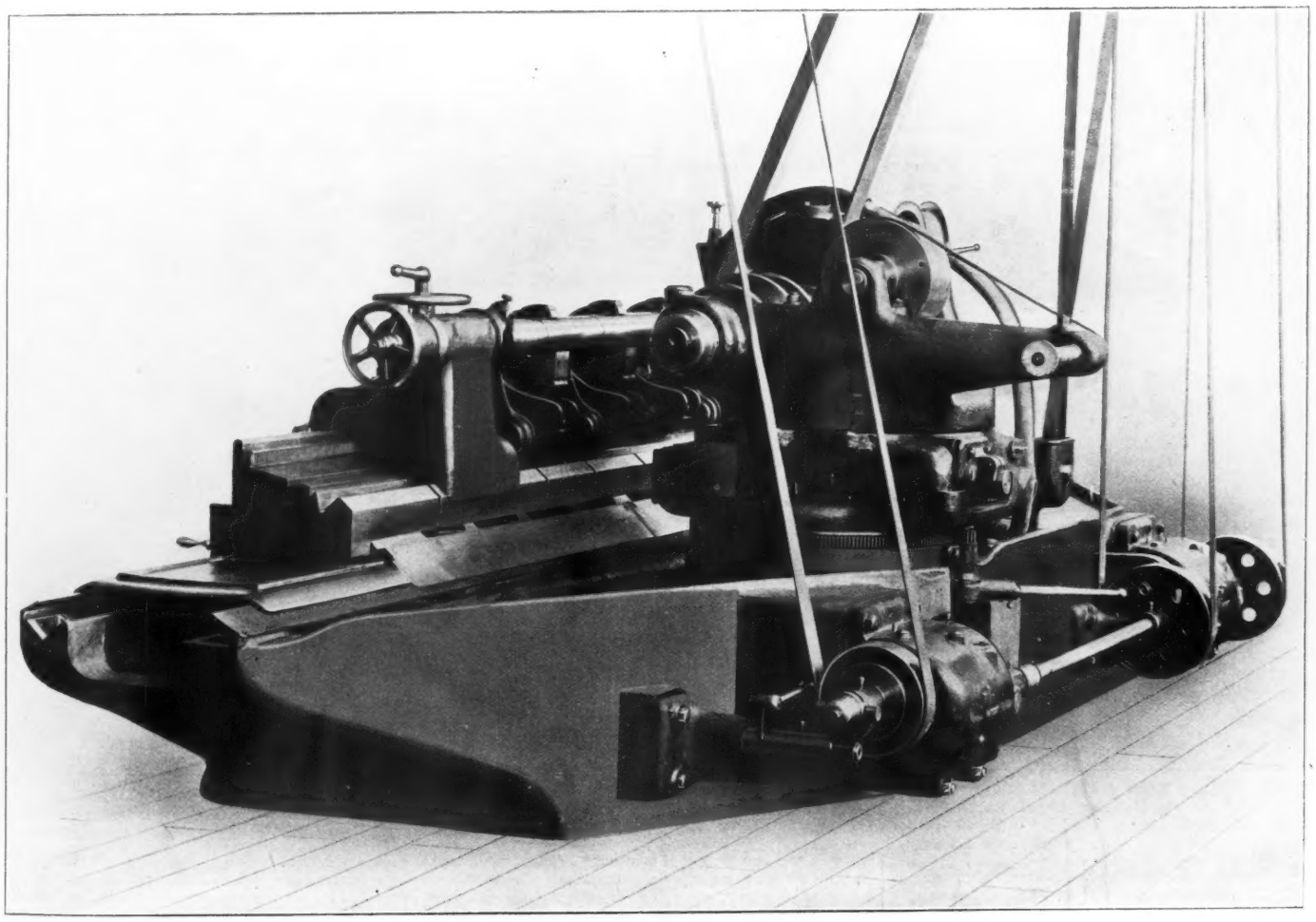


Fig. 32—HERBERT'S LARGE UNIVERSAL GRINDING MACHINE—BACK

longer table beneath it to be used. Owing to the means provided for swinging the table through 90 deg., it is obvious that the longitudinal motion of the table will be used for the feed in one position and for traversing in the other, and correspondingly for the cross motion. Thus two motions, one quick and one slow, are provided for each movement, and it is so arranged that when either slow motion is in use the corresponding quick motion is locked. A water pump of the centrifugal type forms an integral part of this machine, while other accessories and attachments are supplied with it, so as to enable it to encompass the wide range of work for which it has been designed.

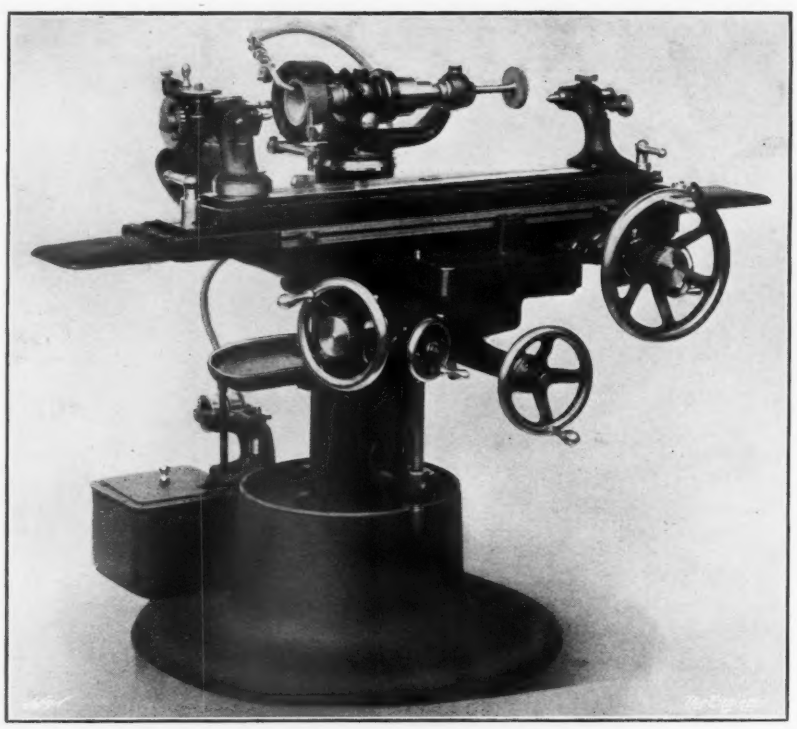


Fig. 33—HERBERT'S UNIVERSAL CUTTER AND TOOL GRINDING MACHINE

Fig. 34 shows an automatic surface grinding machine which has been specially designed by Luke and Spencer, Limited, Broadheath, Manchester, to treat case-hardened and other flat surfaces, hardened dies, &c. It has a rising and falling table to carry the work, while the emery wheel receives a combined reciprocating and rotary motion, the reciprocating motion being derived from a worm and worm wheel clearly shown in the engraving. The traverse of the table is automatic and adjustable, the feed being applied by means of a hand wheel with worm, worm wheel and screw. The size of the pulley on the wheel spindle is 8in. by 5in., and the working speed 1700 per minute.

An automatic surfacing machine of the planing machine type by the same makers is shown in Fig. 35. The machine has hand and automatic longitudinal and cross traverse movement and vertical adjustment, together with automatic reciprocating movement of the grinding head. It is provided with fine adjustment throughout. The feed mechanism operates at the end of each return stroke, and there is no automatic knock off. The cross feed is positive and the vertical feed is by hand, the machine being belt driven. The bearings for the ments. It has self-acting longitudinal traverse motion, and adjustable stops for automatic reversing. The cross slide is of sufficient length to enable the grinding wheel to grind up to the maximum capacity of the machine without overhang. It is fitted with hand gear for feeding the grinding wheel on to the work, and also to give vertical adjustment to the full capacity of the machine. All handles and levers for operating and controlling the machine are conveniently placed for the operator, and the feed-gear mechanism is arranged to permit of fine adjustment. The grinding wheel spindle is of hardened steel accurately ground and lapped, revolving in phosphor bronze bearings, adjustable to take up wear in all directions, and efficiently protected from dust and dirt, to work in accurate alignment with the table. The depth of the

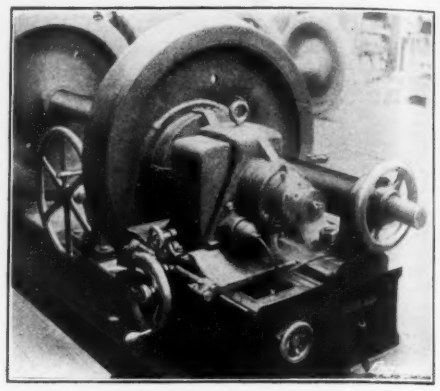


Fig. 36—SCHUCHARDT'S JOURNAL GRINDING MACHINE

cut is controlled by a hand wheel at one side of the machine graduated to read "half-thousandths of an inch." The grinding wheel is made of special corundum, and is 12in. diameter by 2in. thick, mounted on safety dovetail plates. The illustration shows a machine suitable for articles 6ft. long by 14in. wide by 12in. high, but other sizes are made.

The accuracy and fine finish obtainable with modern grinders have both acted towards their adoption in railway shops for many purposes, and in their application to axle grinding we have a typical example of their use. An illustration of this class of tool is shown in Fig. 36. This machine, which is made by Messrs. Schuchardt and Schutte, of Berlin and London, consists of a strong cast iron bed piece, on which are formed two uprights to carry the grinders and the headstocks, the distance between centres being adjustable to suit different gauges. The

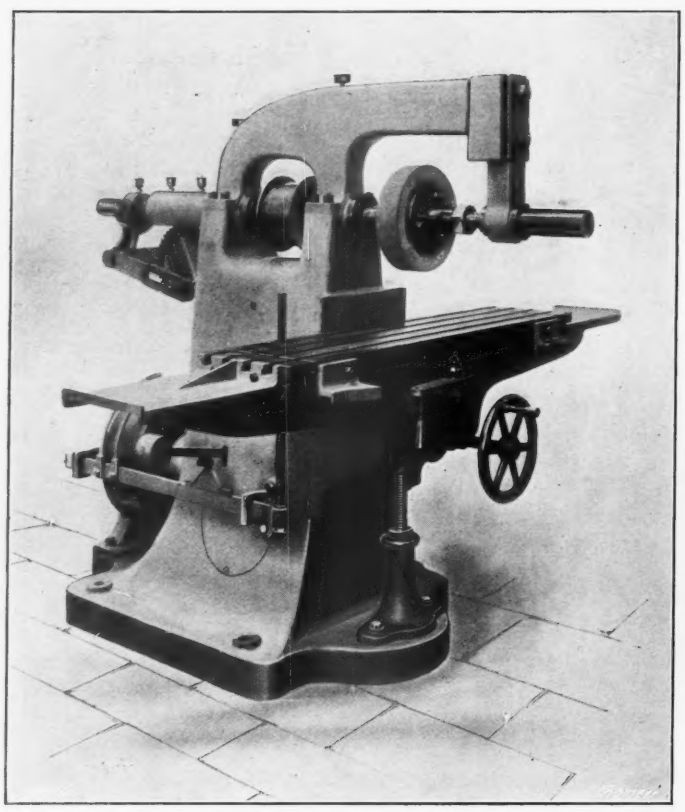


Fig. 34—LUKE AND SPENCER'S FLAT GRINDER

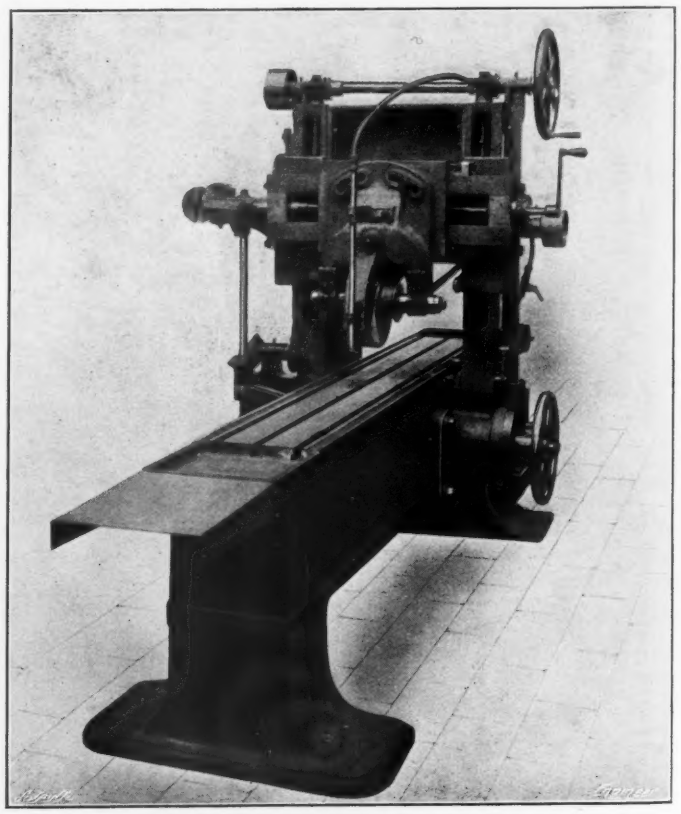


Fig. 35—LUKE AND SPENCER'S SURFACE GRINDING MACHINE

which has been specially designed by Luke and Spencer, Limited, Broadheath, Manchester, to treat case-hardened and other flat surfaces, hardened dies, &c. It has a rising and falling table to carry the work, while the emery wheel receives a combined reciprocating and rotary motion, the reciprocating motion being derived from a worm and worm wheel clearly shown in the engraving. The traverse of the table is automatic and adjustable, the feed being emery wheel spindle are of phosphor bronze, made taper on the outside, being adjustable by means of nuts at each end so as to take up wear and preserve the original alignment. The bearings are secured by means of hinged caps, to allow of readily changing the grinding wheel.

The bed is of strong construction, provided with suitable guides for the table, which is truly surfaced, runs on guides, and is fitted with self-acting lubrication arrange- axles are driven, during the grinding of the journals, by belt from a counter-shaft. A separate electric motor is provided for driving each emery wheel, so that the two journals may be ground simultaneously or independently. For traversing the saddles in a direction parallel to the axles an independent motor is provided for each, the forward motion being secured by screw and hand wheel, When running at 1500 revolutions per minute the grind-

ing motors take about 1½ horse-power each; to alter the speed as may be necessary when the emery wheel wears down a field regulator is provided. Automatic gear is arranged on the saddle whereby stopping and reversing are secured without the intervention of the man in charge. The speed of the auxiliary motors, which give the saddles their longitudinal motion, can also be regulated so that the most desirable speeds for roughing and finishing can be secured. The water details comprise a small electric pump and the necessary storage tanks and pipes. In the engraving we show the details of the saddle from the operator's position.

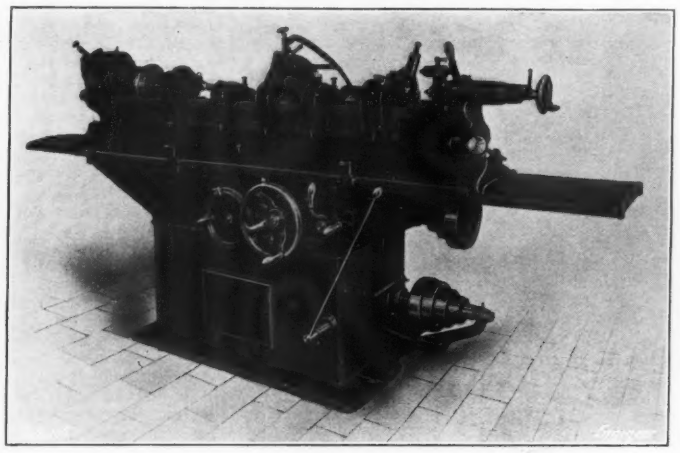
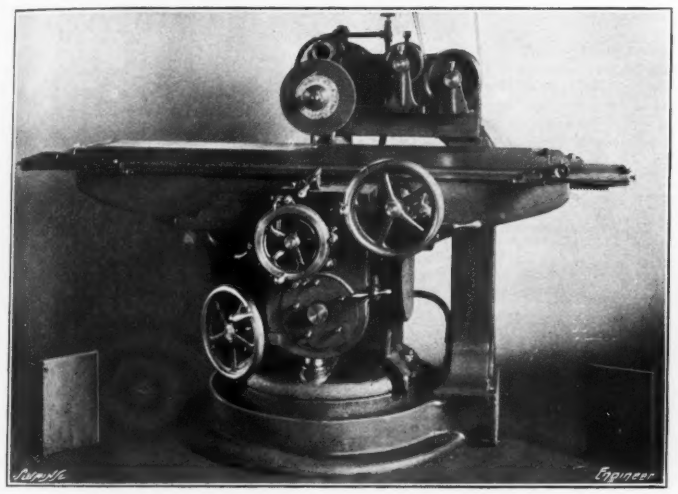


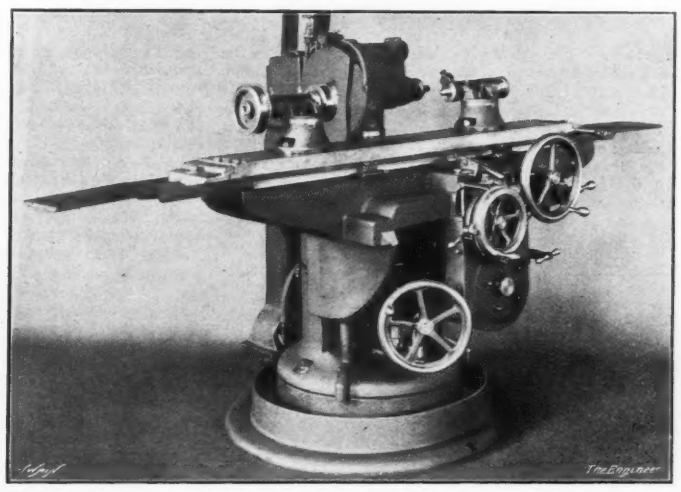
Fig. 37—SCHUCHARDT AND SHUTTE'S PLAIN GRINDING MACHINE

In Fig. 37 is shown a grinding machine, also by Messrs. Schuchardt and Schutte, designed for plain grinding either between centres or in a chuck. In this example, as is common in machines of its class, the wheel remains steady while the table carrying the work is traversed past it. To prevent emery dust from falling on the sliding surfaces of the bed, the table is provided with shields at either end. The grinding spindle is arranged to run at from 1370 to 2950 revolutions per minute, there being twenty four different speeds in this range. Work up to 10in. in diameter and 60in. long can be taken by this machine, the table of which is provided with automatic motion for reversing, and can be worked at the movements involved in the change can be quickly effected and the machine readily adapted for grinding straight or taper work between centres for surface or internal grinding and for knife, die, or cutter grinding. For internal grinding an arm carrying the wheel spindle is attached to the head, the power for driving the spindle being taken from a pulley which replaces the emery wheel shown in the engraving. The table can be traversed longitudinally or across either by power or hand, while to accommodate any variations in its height the drum overhead from which power is

The grinding machine shown in Figs. 40 and 41 differs from most of its class in the arrangements made for driving the emery wheel. A fundamental feature of its design lies in the fact that during grinding operations the wheel is traversed longitudinally, while the work is stationary as far as movement in this direction is concerned. For heavy work, where a crane has to be employed to lift the job into the machine, an absence of overhead belts and shafts is desirable, and for this reason the above machine has been designed by the Landis Tool Company, of Waynesboro, Pa., for motor driving. Referring to the engraving, which shows a view of the machine from the rear, a horizontal shaft carried in brackets secured to the bed of the machine extends along the whole length, and is driven by belt from a motor or countershaft, if so desired. Attached to the grinding saddle so as to move with it is a carriage running on rails beneath the driving shaft. A pulley supported in journals on the carriage drives by means of a belt led over jockey pulleys the emery wheel, the connection between the driving shaft and the carriage pulley being made by rollers working in grooves on the shaft, thereby rendering the longitudinal traverse of the carriage as free from friction as possible. From the left-hand end of this driving shaft a belt is taken to the pulley of a small pump supplying the water for the grinding wheel. From the other end a belt leads to a fast-and-loose pulley at the front of the machine, whence power is transmitted to the variable speed headstock, which provides means for securing ten different work speeds. The machine illustrated is capable of grinding work up to 16in. in diameter, and 72in. in length, while the horse-power required to drive it varies from 15 to 20. Messrs. C. W. Burton, Griffiths, of London, are the agents in this country for the sale of this tool.

John Holroyd and Co., Limited, Milnrow, have just completed the electrically driven 12in. by 48in. machine shown in Fig. 42. The machine has been specially designed for reducing shafts rapidly, and is fitted with a 5 horse-power electric motor, which is fitted on the emery wheel head, and drives the wheel spindle through double helical bevel gearing, thereby dispensing with overhead



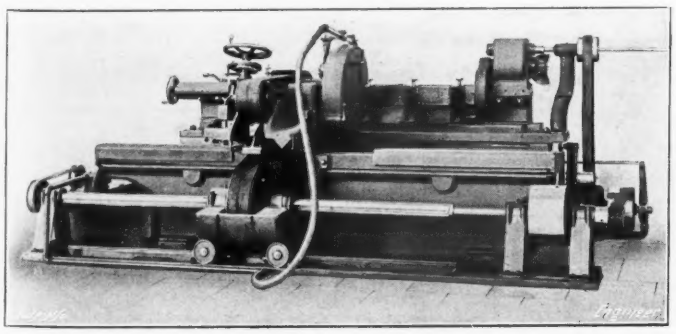


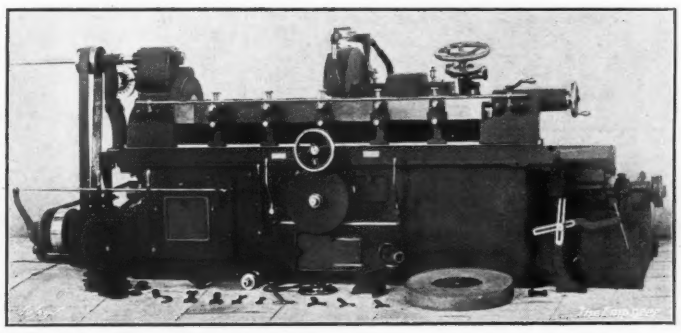
Figs. 38 and 39—THOMPSON UNIVERSAL GRINDER

eight different speeds. In our illustration the machine is shown fitted up with its complement of steadying brackets.

A machine designed to deal with a large variety of work is shown in Figs. 38 and 39. This tool, for the sale of which in this country Messrs. Selig, Sonnenthal and Co., of Queen Victoria-street, London, have been appointed sole agents, is known as the Thompson Universal grinder. The makers claim for it that it can deal satisfactorily with every possible grinding operation required in the machine shop, and that it can, therefore, be installed in place of a variety of specialised machines. In it the head carrying the emery wheel is fixed rigidly in position, and the table with gear attached thereto is mounted on a revolving turret which is carried on the circular base of the wheel post. In Fig. 38 the machine is shown arranged for surface grinding, and in Fig. 39 the table has been rotated through a right angle and the machine altered for grinding between centres. All obtained for driving the work between centres is balanced by a counterweight, so that an even tension is preserved in the belt. A longitudinal traverse of 48in. is provided for, the transverse motion being 8in., and the vertical adjustment 10in. With the ordinary centres supplied with the machine work up to 20in. in diameter and 36in. in length can be accommodated. Higher headstocks are fitted for larger sized jobs. The capacity of the machine for internal grinding can be arranged to suit particular needs, but the ordinary attachment is capable of working up to an internal diameter of 30in. by 4in. deep. All feed motions are finely graduated; as an example we would mention that provided for the cross feed of the table. Here each division on the hand wheel can be made to correspond to a reduction in diameter of $\frac{1}{1000}$ of an inch. Allowing for the full motion of the table in every position, the floor space required for this machine is 13ft. square.

countershafts, long drums, and heavy belts. The motor runs at 1100 revolutions per minute, while the number of revolutions of the spindle is 810 per minute. The grinding wheel is 20in. diameter and 2in. wide. The revolving of the work and the traverse of the emery wheel head are effected by a 2½ brake horse power motor fixed at the end of the machine. This drives a shaft running at 500 revolutions, and extending from end to end of the bed. On the end near the motor is a pulley carrying a 2in. belt, which drives another pulley at the front left-hand of the base, and this drive, after passing through the gear box with a ratio of 1 to 4, drives a two-speed cone. The latter, in turn, drives another two-speed cone on the end of the table, and the power is finally transmitted through the gear box on the fast head to the face plate. This system gives, with belt change and two gear boxes, a range of 16 speeds of the work between 18 and 250 revolutions per minute. The emery head traverse is obtained from





Figs. 40 and 41—LANDIS MOTOR-DRIVEN GRINDING MACHINE—BACK AND FRONT

the same shaft at 500 revolutions per minute. Inside the bed is a drum with 2in. belt, which drives a cone with eight speeds, and fitted with an auto-belt shifter. This drives through gearing which is all attached to a plate on front of the bed, and consists of eight wheels giving a 4 to 1 change and reversing motion through bevels and

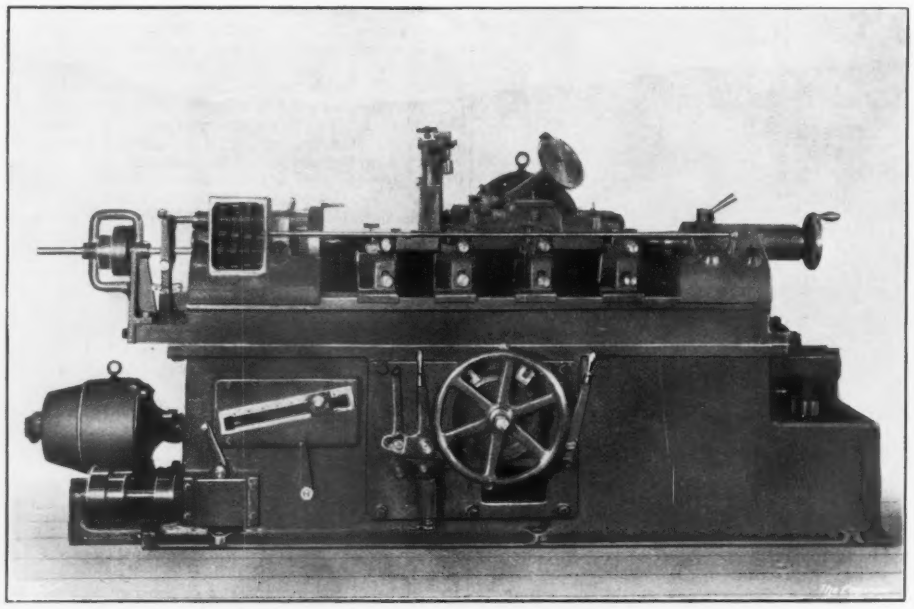


Fig. 42—HOLROYD AND CO.'S ELECTRICALLY-DRIVEN PLAIN GRINDER

shaft to rack gear. This gearing and cone give to the emery wheel slide and carriage a movement of from 8in. to 52in. per minute, with 16 changes and reverse. The reversing motion consists of a circular rack immediately behind the wheel for the hand motion, with stops for actuating rods connected to the reversing lever. The emery wheel head is securely gibbed to a long carriage with flat front and V back slide. It is moved to and from the centres by a hand wheel which works through a worm and wheel to a rack and pinion, a balance weight

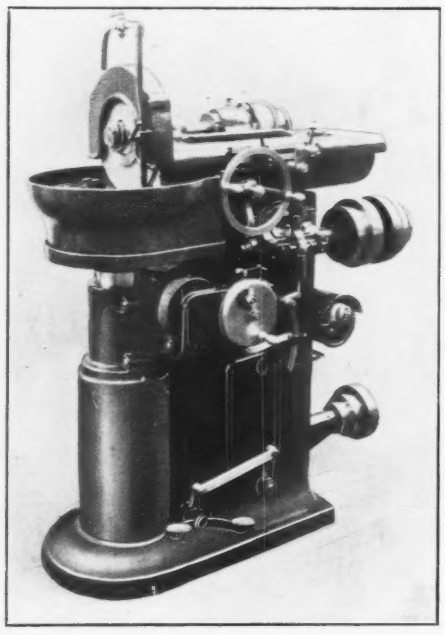


Fig. 43—CHURCHILL RING GRINDER

being provided to keep the wheel from jumping into the work.

A special machine has been designed by the same makers for the rapid and accurate grinding of hobs, spiral reamers and milling cutters. We are unable to find space to illustrate it, but a few words of description may be appreciated. The head which contains the moving, twisting, and dividing gears, is worthy of special mention. The main spindle, which passes right through, is 2in. diameter, and slides in a sleeve. On this sleeve is mounted the differential gear, the centre block of which rotates it. At either side is a worm wheel. One of these wheels rotates slowly for spiral motion, and the other quickly at the end of the stroke when dividing. From a three-speed cone motion is transmitted through bevel gearing to the screw and spindle. This spindle and screw are geared together by change wheels at the end of the head, so as to give the pitch of the spiral grooves. Inside the gear box at the end of the head are three gear wheels, one on the shaft which rotates the spindle, one on the screw, and a centre one on the driving shaft. The last slides so that it can mesh with either of the other two. The change gear wheels for the pitch of the spiral are arranged to have the same number of teeth as are used on the universal miller on which the hobs are gashed. The reversing is effected by a stop-rod and spring catch operating a clutch which moves between two bevel gears on the driving shaft. The main drive is provided by a belt running on a loose pulley, and held by a fork, so that it rubs on a fast pulley sufficiently to drive it instantly when the stop catch is removed. This catch is in front of the machine, and is operated by the same lever as is the reversing clutch. On the front of the fixed headstock is a set of change wheels, the ratio of which is such that one revolution of the stop catch disc divides the hob correctly. The driver plate on the end of the spindle is provided with a worm and worm wheel, and small star wheel, so that the hob may be turned for the purpose of putting on the cut. The operation is as follows:—The machine having the hob in place, is started, the hob moves forward, revolves under the emery wheel, until the two run clear of one another. Then the machine reverses, and the backlash in the gears, &c., carries the emery wheel clear of the hob. At the end of the backward movement the reversing operation also withdraws the dividing stop catch, and the hob is moved round to the next gash. At the end of one revolution of the hob the star wheel on the driver plate is moved one tooth, thus revolving the hob forward slightly.

An extension at the back of the base of the machine provides a support for the slides which carry the emery wheel. The spindle revolves in long parallel bearings cast on the head, which is arranged to swivel to any angle. There are two handles for swivelling, and two for locking. The grinding head is carried on heavy slides with vertical and cross adjustment and compensating belt drive. There are no weights or jockey pulleys. The machines can also be fitted with a worm grinding attachment. In this case the emery wheel head is fitted with a vertical slide which is arranged to swivel. This slide carries the emery wheel which has automatic down feed by means of a ratchet. The vertical slide is set at the same angle as the thread of the worm, and at each traverse of the table a ratchet is tripped, thereby giving a feed to the emery wheel down the inclined face of the worm thread. When one side of the worm has been ground, the head is swivelled over to the opposite angle or the worm turned round between the centres, and the other side is ground in the same manner. The belt for driving the emery wheel is arranged to run over jockey pulleys in such a manner that the tension is the same whatever the position of the emery wheel may be.

The plain grinding machine shown in Figs. 44 and 45 has been designed by the Churchill Machine Tool Company, and is chiefly intended for operating on spindles, shafts and rods which can be revolved between dead centres. It is essentially a manufacturing machine, and embodies conveniences for rapid manipulation. The makers have given special attention to the method of fixing the work heads to the table to ensure rapidity and accuracy of alignment. The machine follows standard practice, but in connection with the table travel, a slow speed is provided independent of the ordinary speeds. This arrangement enables a fast speed to be used for roughing out and a slow speed for finishing cuts. The steadies for this machine, Fig. 44, are fixed where needed directly to the table, and besides giving a very rigid support to the article being ground, are easy of adjustment vertically and laterally. It will be noticed that the work table is on an angle, thus obviating the use of loose water guards. The table swivels and enables tapers up to 2in. per foot to be ground. The pump is of the vertical centrifugal pattern, always primed, and not affected by grit. The machine shown is capable of accommodating work 10in. by 90in., and the table speeds are twelve in number, operated from the front of the machine through a gear box,

The following are the leading particulars of this size of machine:—

Maximum swing	10in. dia.
,, length	90in.
Will grind taper to	2in. per ft.
Wheel spindle bearings	3¼in. by 7¾in.
Size of wheel	20in. by 2in. or 3in.
Number of wheel speeds	4
,, work speeds	12

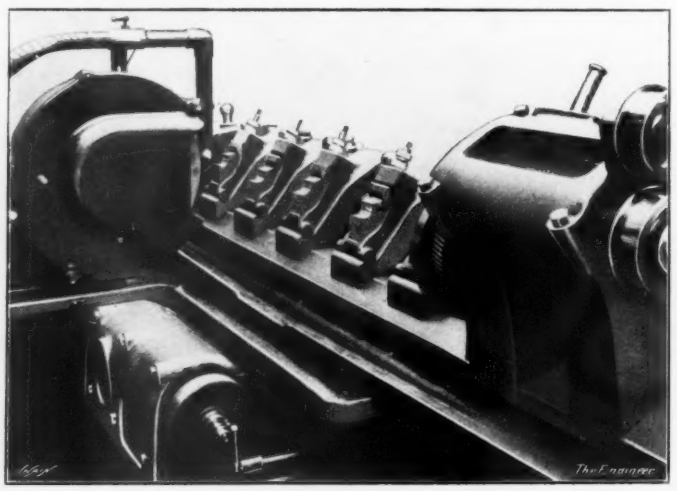


Fig. 44—CHURCHILL PLAIN GRINDER—BACK

Number of table speeds	12
,, work rests	5
Fast and loose pulleys	12in. and 16in. by 5in.
Speed of ditto	540 and 405 r.p.m.
Floor space required	14ft. 6in. by 4ft.
Approximate net weight	5½ tons.

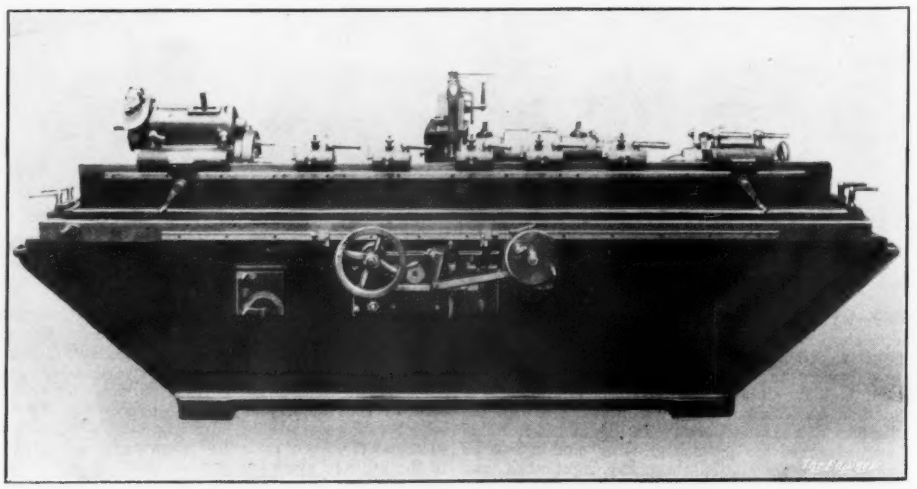


Fig. 45—CHURCHILL MACHINE TOOL COMPANY'S PLAIN GRINDER

Fig. 46 represents a ring and surface grinder made by the Churchill Machine Tool Company. The body of the machine carries a long sleeve, in which revolves a vertical spindle supporting a magnetic chuck. The sleeve has a micrometer vertical adjustment and power feed with automatic stop, enabling a large number of pieces to be ground

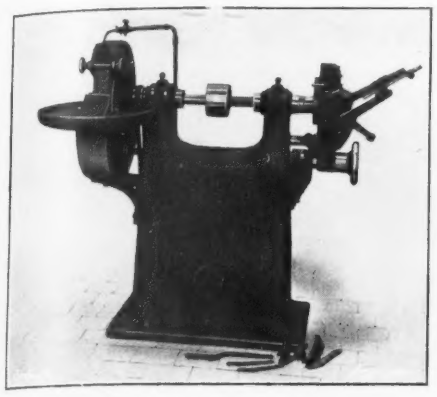


Fig. 46—MITCHELL'S GRINDER

to absolutely identical thickness. The feed operates at each end of the stroke, and can be varied between .0001 and .00075in. The magnetic clutch is specially made to allow for wet grinding, and has six changes of speed for varying diameters of work. It can be instantly stopped without stopping the machine. The chuck grips or

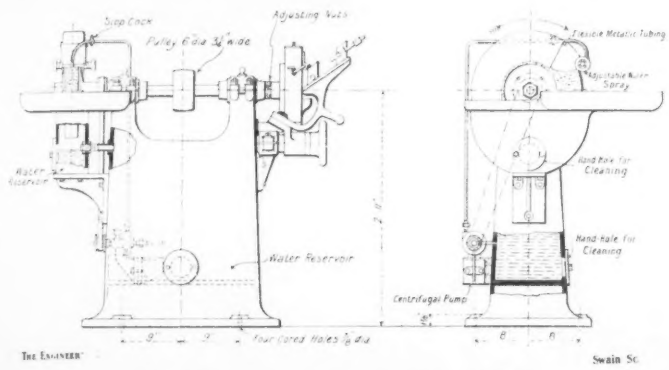


Fig. 47—MITCHELL'S TOOL AND DRILL GRINDER

releases the work by the pressure of a button, and requires direct current of 110 to 220 volts, using no more power than an ordinary lamp. The grinding wheel traverses across the work, and is carried on a slide which is adjustable to grind clearance on saws, cutters, &c. The wheel slide is fitted with hand traverse and two rates of power feed, the position of the wheel and the amount of travel being controlled by means of adjustable dogs shown on the front of the wheel slide. Two speeds are provided for the grinding wheel, and the wheel spindle is hardened and ground, and runs in adjustable bronze self-oiling bearings. The pump is arranged to give an ample supply of water to the wheel, and suitable guards obviate splashing.

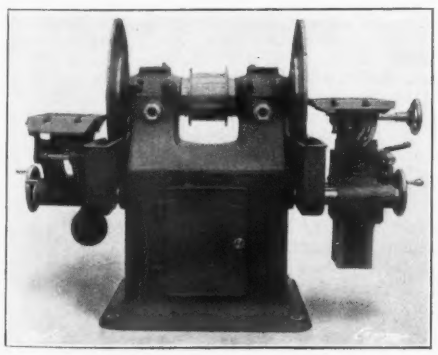


Fig. 48—ROBERT'S DISC GRINDER

The chuck is 12in. diameter, the grinding wheel 12in. by ¾in., and the vertical adjustment 4½in.

Mitchell's Emery Wheel Company, Manchester, have quite recently introduced a combination machine which will be found particularly useful in engineering workshops. It is a combined tool and twist drill grinder, and is clearly illustrated in the accompanying illustrations—Figs. 46 and 47. The left-hand side is fitted with a 16in. by 2½in. corundum wheel, which runs in a trough, and has a hood to prevent splashing. The trough and the base both form water reservoirs, and the outlet from each is arranged at a high point so as to allow the grit and heavy grindings to settle and the water to pass as clean as possible. They are each provided with mud-hole and cover, enabling the machine to be cleaned without the necessity of taking it to pieces. The pump on the back of the machine, which is driven off the wheel spindle, is of the centrifugal type, and is unaffected by gritty water. Neither does it require a relief valve when the water is shut off at the stop cock. The spindle of the pump is provided with a packed gland.

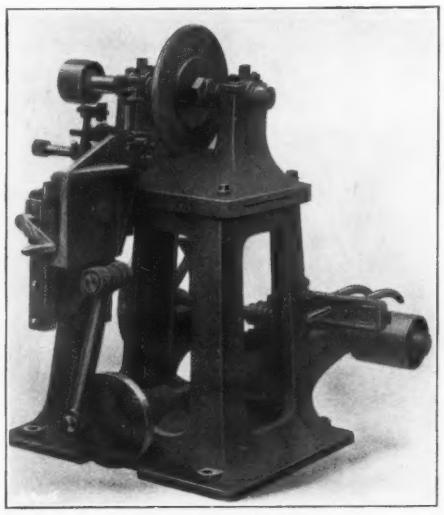


Fig. 49—STERNE'S TOOTH GRINDER

No rubber tubing is used for the water supply, all the connections being of metal throughout. The water is delivered by the pump to a spray nose piece on the hood, which is adjustable to follow the wear of the wheel. At the right-hand side of the machine there is a 9in. corundum wheel, with 1½in. face, and provided with a special water shield. A tank is formed on the top of this shield into which the wheel, acting as a pump vane, forces the water. This tank is provided with a pipe, which again conducts the water on to the point of the drill which is being ground, and there is a tap for shutting off the water when not required. The wheel spindle is 1½in. diameter, and runs in ring lubricated bearings of ample length. It has a hardened steel nut and lock nut for taking up end play. The oil reservoir to each bearing is of good size, and is provided with an oil gauge and inspection hole and cover for replenishing. The

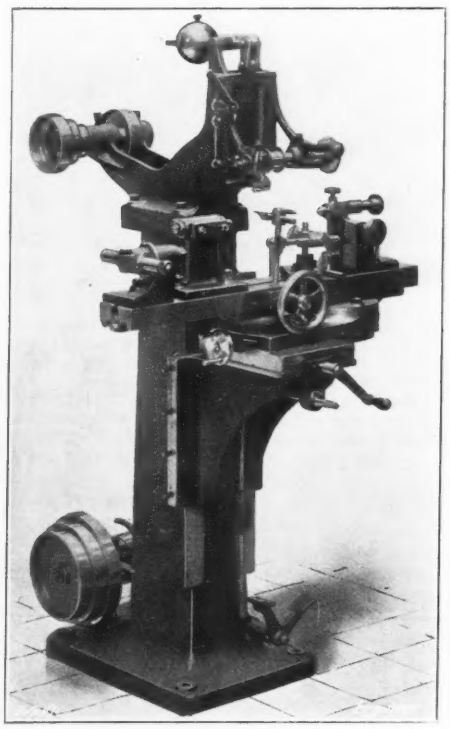


Fig. 50—ARCHDALE'S CUTTER GRINDER

pulley is 6in. diameter, and wide enough for a 3in. belt, the speed being 1100 revolutions per minute.

The grinder shown in Fig. 48 has been designed by Roberts Brothers, Dukinfield, Manchester, and is intended for the heavier kinds of work. These makers have, as our readers are aware, made a special feature of disc grinders. The table on the left-hand side has micrometer adjustment of 3in. to and from the disc by means of a screw and hand wheel, and has a counterbalanced rocking motion across the face of the disc. The table on the right-hand side is vertically adjustable through 13in. by worm and wheel, a quick cross traverse of 8in. by rack and pinion, graduated angular adjustment and micrometer adjustment to and from the disc. Both tables are slotted out for securing the work. The diameter and length of the spindle bearings are 2¼in. and 10in. respectively, and the system of lubrication is by rings in a well-known manner. The width of the pulley is 6in., the height of spindle centre from the floor 3ft. 3in., the size of the universal table 17in. by 14in., and of the rocking table 16in. by 12in. In this firm's grinders "anti-vibrating" plates are shrunk on the spindles and turned between dead centres. They vary in diameter according to the size of the disc, and besides giving additional support to the disc when operating on large work, prevent buckling taking place. Between the plates and the discs fibre washers are inserted to break up the sound waves and render the machine noiseless. Although this firm makes machines fitted with automatic micrometer feeds, their experience does not warrant them in

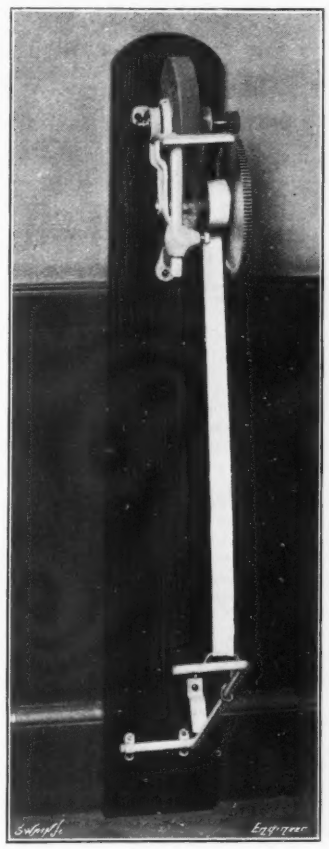


Fig. 51—CROSIER AND STEPHENS' TREADLE GRINDER

recommending this form of mechanism, because however fine the pitch of the thread may be the correct feed is never obtained, with the result that if the work is advanced too quickly the emery disc is liable to be destroyed, and if advanced too slowly there is a corresponding loss in economy.

The machine shown in Fig. 49 is designed for grinding up the teeth of wheels, rollers, saws, &c., and has been made by L. Sterne and Co., Limited, Glasgow. The emery wheel, 14in. diameter by ¼in. thick, and bevelled to suit the angle of teeth, is mounted on a strong steel spindle by means of turned cast iron washer plates and nuts. The machine carries its own countershaft complete with fast and loose pulleys and a belt shifter. A compound slide rest is fixed to the stand of the machine for carrying the work which is fixed to the top of the horizontal slide. The vertical slide is raised and lowered automatically by a crank and connecting-rod arrangement, actuated by worm gearing from the countershaft. At the end of each stroke the roller is automatically moved round one tooth, thus allowing the teeth to be uniformly ground. An adjustable steadying arrangement is fitted to the slide rest to prevent the roller from turning while being ground. The work is traversed to and from the emery wheel by hand.

Fig. 50 illustrates a universal cutter grinding machine, made by Archdale and Co., Limited. In it the spindle is hardened, ground true, and runs in conical bronze bearings. It is carried in a slide, with V guide and adjustment for wear, and is balanced by a counterweight for use when "copy" or "former" grinding is being done. The table has traversing motion in either direction, and is provided with adjustable stops. It is indexed and arranged to swivel to any angle up to 90 deg., and has vertical and longitudinal adjustment, with extra adjustment to the upper slide. The machine is entirely self-contained, and no countershaft is required. The height of centres is 5½in.; the size of table, 2ft. 8in. by 4½in; and the machine will admit between centres, 1ft. 6in.

As an example of a foot-power machine, we illustrate in Fig. 51 a self-contained treadle grinder which has been designed and made by Crosier,

Stephens] and Co., of Newcastle-on-Tyne. It is intended to be used not only when there is an absence of mechanical power for driving purposes, but also in any large factory where, its makers claim, it will greatly economise the time spent in the periodic grinding to which tools are subjected by the machinist himself. The frame of this machine is of cast iron, and as shown in the illustration, it is intended to be fastened to a wall or pillar. A hardened steel spindle carries the corundum wheel, and runs in hardened ball bearings. The wheel, measuring 8in. by 1¼in., acts as a fly-wheel, and the

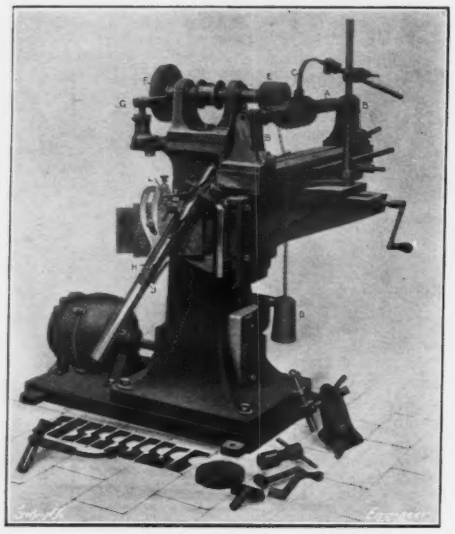


Fig. 52—HULSE'S CUTTER AND DRILL GRINDER

makers state that a speed of 3000 revolutions per minute can be easily attained with the foot gear. A machine-cut fibre pinion is mounted on the spindle, while a ball clutch is interposed between the band pulley and the larger gear, which thus allows the grinding wheel to be rotated continuously in one direction by an occasional stroke with the foot.

A motor-driven combined milling cutter and twist drill grinding machine, made by Hulse and Co., Limited, Manchester, is illustrated in Fig. 52. It is shown set for grinding cutters, which it can take up to 6in. diameter and 20in. long. It has also a twist-drill grinding attachment, which is readily brought into position or swung clear, and can be used on drills from ¼in. to 3in. diameter. The main frame is of box form, and the fast headstock has a conical steel spindle running in hard gun-metal bearings. The table has vertical, longitudinal, transverse and swivel slides, and is hinged so that it can be swung out of the way. For grinding edge cutters these are keyed upon an arbor A, which is placed between the movable headstocks B. The guide finger C is adjusted to the position indicated, and the cutter to be sharpened is held up against it by means of the chain and weight D. The emery disc E is put in motion, and the back of the tooth of the cutter next above the centre line of the headstocks is brought against its lower face. The cutter is then traversed quickly once or twice transversely by means of a handle—omitted in the illustration—and a cutting edge is produced. To bring another tooth into position the table is traversed endwise by the handle above alluded to till the cutter is clear of the finger, and the latter is then engaged with the tooth next to that which it was previously engaged in, without alteration or adjustment. The operation is then repeated. When the machine is to be used for sharpening twist drills, the cutter grinding table can be swung aside, and the grinding apparatus is brought into position and held by nuts. A disc of suitable shape is substituted for the cylindrical disc used for sharpening edge cutters. Sufficient clearance behind the lips of the drill is first ground by means of the disc F on the rear end of the spindle and the rest G shown. The drill H is next placed with its shank end in the drill headstock centre J, its upper end being supported in the plate K shown, a set of which are provided to suit drills of different sizes. The bracket is adjusted radially to the required angle, and has an indexed slide at the top to receive the plate mentioned. These plates are set one or two degrees to the right to give the requisite clearance. The guide finger L is adjusted to the position shown, and holds the lips of the drill at right angles to

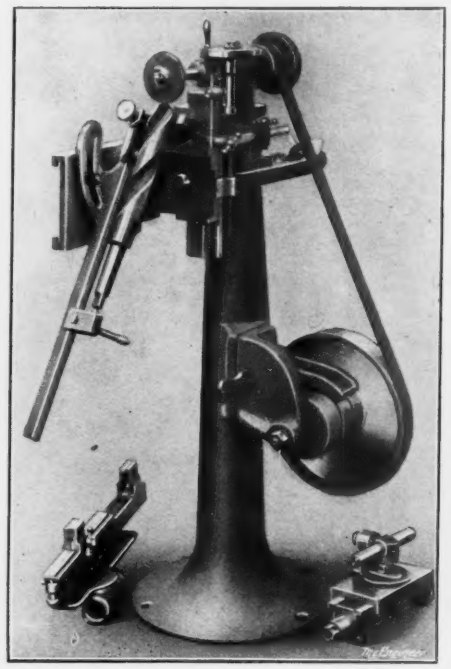


Fig. 53—LANG'S DRILL GRINDER

the emery disc by which they are ground. After one lip has been sharpened by traversing it by means of the horizontal slide across the bottom of the emery disc, the drill is taken out from below without disturbing the guide

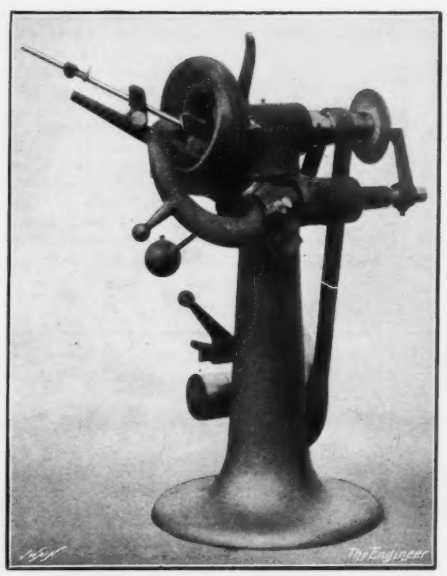


Fig. 55—HERBERT'S TWIST DRILL GRINDER

finger, plate, or headstock, is turned half round, and the other lip is similarly ground. The machine is arranged to be driven by means of a belt from a self-contained one brake horse-power constant speed motor.

In Fig. 53 is shown a machine designed and constructed by John Lang and Sons, of Johnstone, for sharpening twist drills, rose bits, reamers, taps, milling cutters, and other small tools. For drills it is arranged to take all sizes from ¼in. to 3in., and it can be quickly changed to suit the varying sizes of the tools, while an easy adjustment allows alterations to be made in the angle given to the cutting lips. The machine carries its own countershaft, and from this a belt is led to the pulley on the grinding wheel spindle. This spindle is provided with corundum wheels at both ends, the smaller wheel being used for the lip-grinding operations, while the larger is intended to be used for the preliminary process of giving the requisite clearance to the drill point.

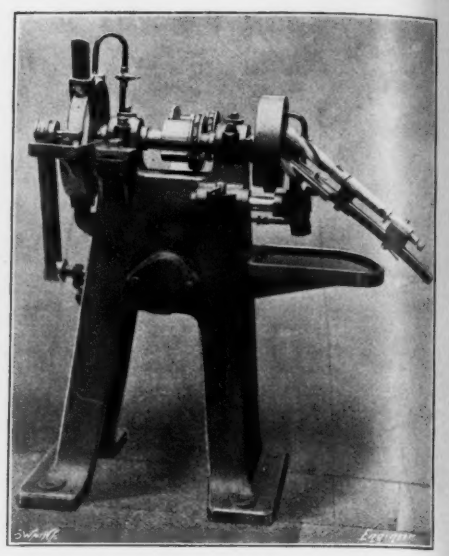


Fig. 54—ROWLAND'S TOOL AND DRILL GRINDER

The saddle carrying the drill is arranged to slide horizontally, and a hand wheel and screw give the vertical feed required. An adjustable arrangement is provided for directing a supply of water on to the drill during grinding.

A combined wet tool grinder and twist drill grinder made by B. R. Rowland and Co, Limited, Reddish, near Stockport, is illustrated in Fig. 54. This compact machine is fitted with a belt driven centrifugal pump for supplying water to the grinding wheels. It is of rigid construction, and on a bracket at the back there is provided a small wheel for thinning the points of twist drills. The machine is fitted with self-oiling bearings.

The twist drill grinder shown in Fig. 55 has been constructed by Alfred Herbert, Limited, of Coventry, with a view to producing a machine which will have increased means of resisting the deleterious action of the wheel swarf and tool dust, while possessing accuracy and convenience in operation. The spindle is mounted on dust-proof and watertight ball bearings of the single track type. These bearings, the makers state, run perfectly cool, and need to be lubricated only at very long intervals. The spindle with its bearings is adjustable bodily in an axial direction for putting on the cut, and to compensate for the wear of the wheel, the oscillating drill holder being fixed in this respect. The end play of the spindle is automatically taken up by a spring. The water supply is contained in the casing which acts as a guard for the wheel, and circulation is set up by the rotation of the wheel which acts as a centrifugal pump, a separate pump being thus unnecessary. A wheel trueing apparatus is carried on the casing, and is always ready for use without disturbing any of the adjustments of the machine. During grinding operations the drill holder automatically sets the drill in the correct position with regard to its diameter, so as to produce the proper conical clearance surface. As the drill holder is not adjustable to and from the wheel, it is at all times rigidly clamped to the column, and is, therefore, very stiff and well supported. The position of the axis of oscillation on this machine is such that the clearance angle of the drill increases progressively towards the centre, thus producing durability of the cutting edge of the sharpened drill. The countershaft, with its fast and loose pulleys, is carried by the column of the machine and runs on dust-proof single-track ball bearings. A grinding wheel for thinning the points of drills is carried on the rear end of the spindle.

NOVEMBER.

The Swansea Harbour Trustees are to be congratulated on the early completion of the new King's Dock, which was formally opened on the 23rd November. The work, which was commenced in July, 1904, has been completed nearly eight months before the contract date, and adds 68 acres to the previously existing water area of the docks. The principal trade of the new dock will be coal, and the arrangement of the berths, sidings, and approaches to the quays have been specially designed with this class of traffic in view. Practically the whole of the coaling jetties and wharves are constructed of reinforced concrete, and constitute the most extensive work which has hitherto been executed in this material in connection with dock or harbour works in this country. The most noticeable feature of the dock works is the exceptionally large proportion of quay frontage to water area. The completed quayage exceeds 13,500ft. in length, and this accommodation has been obtained without unduly restricting the water area and manœuvring space within the dock. Practically the whole of the work has been constructed on a site which was the foreshore of Swansea Bay until its enclosure by a sea embankment nearly two miles in length, within which the dock and its accessory works have been built. The entrance lock is 875ft. long, 90ft. wide, and has a depth of 40ft. over the sill at high water of spring tides. The Trustees have made ample provision for future extensions of the dock on a large scale, and it will be possible nearly to double the accommodation now provided in the King's Dock by a comparatively small expenditure on quay walls and equipment. In a later issue we shall publish a further instalment of an illustrated description of the dock works.

If the vast irrigation project which Sir William Willcocks has prepared for the rehabilitation of Mesopotamia is realised and proves only half as successful as the Assuan barrage and irrigation scheme, with which he was so closely associated in the earlier stages of its development, he will have initiated a work which will have immense effect in the material development of a large area in Asiatic Turkey, and be one of the great engineering feats of modern times. Sir William has been engaged for some years in elaborating his scheme, which he described before a meeting of the Royal Geographical Society on the 15th November. It is only since the advent of the present Government in Turkey that the scheme has entered the realm of practical politics, and funds have at last been assigned for an immediate commencement of a part of the works. Briefly, three millions of acres of the best land in Mesopotamia will be irrigated by means of the construction of a system of canals, weirs, and barrages in the Tigris-Euphrates delta, and the scheme provides for extensions, which, in days to come, may add still another three millions of acres to the land under irrigation. The first section of the work, providing for the diversion of the surplus waters of the Euphrates down the valley of the ancient Pison, will occupy three years in execution. Canals, regulation weirs, and barrages will follow in due course, and by their construction it will be possible not only to irrigate vast areas of land, but to separate the pernicious silt which is carried by the waters of the rivers at certain periods of the year, and allow it to deposit in the great Akkar Kuf Lake, which lies in a depression between the Euphrates and the Tigris. The scheme also provides for the construction of several lines of railway, including one from Baghdad to a point on the Mediterranean, near the ancient cities of Tyre and Sidon, to bring the harvests of cotton, wheat, and other products to the coast markets.

A colliery fire of an exceptionally disastrous character, involving the loss of nearly 300 lives, occurred at Cherry, in the northern part of Illinois, on November 13th. The St. Paul mine, in which the disaster occurred, is lighted by electricity, but the cable in one of the levels had given out, and pending the supply of a new cable oil "torches" were being used in this part of the mine. Some bales of hay were being taken on a truck to the mule stables, when, apparently, one of the bales ran into or near to the flame of one of the torches. The men seem to have lost their heads, and hurled the bale into the shaft in the expectation that it would be quenched in water in the sump. Instead of that, it set fire to the timbering of the lower level, and the fire spread with great rapidity. Efforts were made at rescue, but unavailingly, and the mine had eventually to be sealed. There are, of course, many conflicting statements. The company and its officers state that the mine was safe and well equipped, that the men were careless in handling the hay, and when they found it on fire they could have sent it up at once on the cage. The miners, on the other hand, say that the mine was not safe, there were no fire-extinguishing appliances, the timbering was dangerous, and should have been replaced by brick or concrete at the entrance to the shaft, and that reckless methods were allowed when the electric light system got out of order. They state also that the alarm was not given to the men until two hours after the fire was discovered. Investigation will doubtless bring to light the true facts of the case, but there appears to be no possibility of doubt that from 250 to 300 men have lost their lives in this terrible and sudden disaster.

The report of Mr. W. W. Squire, the engineer to the Bristol Docks Committee, who was appointed by the Home Secretary to attend the inquest which followed the disaster at the Newport Alexandra Docks Extension Works on July 2nd, was issued early in the month as a Parliamentary paper. Mr. Squire's report details the incidents leading up to the disaster, and describes what actually took place, so far as we are ever likely to know. The plans and illustrations accompanying the report enable readers to follow the details of the description, and to appreciate the methods of construction adopted by the contractors, Messrs. Easton, Gibb and Son. Mr. Squire fully exonerates the contractors from blame in connection with the accident, and points out that the only person who might have been fully acquainted with all the circumstances of the collapse of the trench—the walking ganger, Ratcliff—died before his evidence could be obtained. The only criticism Mr. Squire is prepared to make is that it seems to be open to question "whether there was sufficient communication between Ratcliff and his men on the one hand, and between him and his superiors on the other hand." The report emphasises the fact that in trench work of the nature of that carried out at Newport, the risk of danger has already arisen before the remedy can be taken in hand. As to the cause of the disaster, Mr. Squire says little or nothing definite. In fact, the report is inconclusive in this respect, and with regard to the prevention of similar accidents in the future, recommends nothing, except the exercise of great care and prudence. The report does, however, contain a recommendation in agreement with that made by the jury at the inquest, as to the desirability of instituting an inquiry as to how the risks associated with this class of work may be minimised.

Ten days ago the London County Council considered a long report on apprenticeship and trade schools and came to the decision, first, that in view of the national character of the work done in the schools, the Government might be expected to increase the present grant, and, secondly, that the Board of Trade should be invited to assist the *protegés* of the Council through the medium of the Labour Exchanges. We sincerely trust that the result of the decision may be a thorough investigation of the technical training of artisans as it is now conducted. There are very good reasons for believing that the trade schools are not worth a fraction of the sum annually spent on them. On the other hand, the old system of apprenticeship is hardly likely to be revived; it was killed by the factory system, and as long as the factory system endures a return to the apprentices of old is impossible. There is, however, no reason why an improvement of the present system should not be made, and we are glad to find that under the energetic action of the Lord Mayor something is likely to be done. It is, however, earnestly to be hoped that practical employers of labour will be consulted, and that more attention will be given to their opinion than to that of professional educationalists whose understanding of practical factory economics is only too often, as the Council report shows, sadly small.

Following upon the catastrophe to the dirigible balloon, République, the French journal *Le Temps* opened a national subscription with a view to replacing it with one or more airships, and the amount collected, reaching not far short of a million francs, will probably be devoted to the purchase of a dirigible balloon as well as a number of aeroplanes. Meanwhile, the question of providing France with an aerial fleet is seriously occupying the attention of our neighbours, who are alarmed at the progress being made in Germany, where an organised fleet of dirigible balloons is already in existence with suitably equipped sheds at the different strategical points. The organisation is so perfect that production of hydrogen gas has been placed under State control, and wherever the gas is manufactured hydrogen cylinders are stored on wagons ready to be attached to any train to be consigned to any part of the territory at a moment's notice. The army balloon corps is, moreover, constantly familiarising itself with the management of dirigible balloons, ascents being made at all times and in all weathers. Although our French friends are seriously alarmed over the advance made by Germany in creating a fleet of motor balloons, and are urging upon the Government to lose no time in recovering lost ground, it is probable that the inaction of the French military authorities is due to their qualified faith in the dirigible balloon, which is recognised as undoubtedly valuable for revealing masses of troops. But it cannot be relied upon in all weathers, and the French authorities are of the opinion that the aeroplane will be developed sufficiently to allow of this work being done equally well and under much better conditions. Quite a number of aeroplanes can be built at the cost of one motor balloon. While the French are hesitating, the Germans are doing their best with what they have at hand, and possess at present the strongest and best equipped aerial fleet in the world.

The first important discovery of natural gas in Europe is reported from Kis-Sarmas, in the county of Klausenburg, in Transylvania, where an apparently inexhaustible supply has been found. The presence of this valuable economic asset first became known some two years ago, when shepherd boys used to light the vapours rising from the marshes, to the terror of the ignorant country people. Upon a geologist's report the Ministry of Finance directed proper borings to be made, when large quantities of gas were discovered at a depth of 20 m. The borings were continued to a depth of 200 m., when the gas was found in such immense volume that big stones, as large as a man's fist, were thrown into the air by it. At the present time the gas is pouring out of a pipe 20ft. above the ground with a noise that can be heard six miles away. Experts estimate the flow at 70 cubic feet a second. Analysis shows that it is a peculiarly clear methane gas, containing scarcely half of 1 per cent. of nitrogen. A Government commission of experts declare that there is little danger of the supply becoming exhausted, and even if the pressure becomes less in a few decades, new borings would certainly yield large additional quantities of gas. Upon the advice of these experts the Hungarian Ministry of Finance have bought all the gas mining rights for 100,000 crowns, or rather less than £4200. It is proposed to utilise the gas supply in running a large central electrical plant to be built on the ground.

By introducing a Bill that will confer a certain self-government on the ports, the French Government aims at putting an end to a state of things which has always been regarded as a serious grievance by local interests. At present the Chambers of Commerce have no real jurisdiction over the ports, which are under the direction of engineers appointed by the State, and nothing can be done without official sanction, with the result that the administrative machinery moves very slowly on account of the endless formalities that have to be observed. The impossibility of carrying out extensions or improvements without being hindered by red tape at every turn has long exasperated the Chambers of Commerce, which find their own ports practically at a standstill, while the ports of other countries are developing rapidly. Another grievance is that port dues are levied by the State, and are not always utilised for local improvements. The new Bill, however, is giving some satisfaction to the Chambers of Commerce, although, in many respects, it is open to criticism. It is intended to create in each port a Board of Management, of which the chairman will be the chairman of the Chamber of Commerce. He will represent the commercial interests, while the technical work will be undertaken by an engineer appointed by the Minister of Commerce as at present. The Board of Management will be elected partly by the Chamber of Commerce and other local bodies, and partly by the Minister of Commerce, and it is pointed out that under this arrangement the State will still have the upper hand, with the result that there may be friction between the official and local elements. The Chambers of Commerce have always wanted to have complete control over the ports, without State intervention, and they are therefore only getting partial satisfaction by the new arrangement. Nevertheless, it is admitted all round that the appointment of new Boards of Management is a move in the right direction, since it aims at giving local bodies a prominent voice in all matters affecting the ports and suppressing all useless and irritating formalities, whilst at the same time it leaves the management of the ports still under the control of the State.

The piercing of a tunnel which will undoubtedly have a very considerable effect on the future of the Argentine and Chilian Republics, if not on the commerce of the world, was finally completed during the month. We refer to the tunnel through the Andes connecting Las Cuevas in the former state with Caracoles in the latter, which, when it is finished and laid with rails, will form the last connecting link on the first transcontinental railway in South America, joining the Pacific and Atlantic Oceans, Buenos Ayres and Valparaiso being the respective termini. The total length of the tunnel is about 3165 m. —say 1.97 miles, this length including two artificial ends at either side, together 142.70 m. long—and it has been driven at the great elevation of 10,500ft. above sea level

by a British firm, C. H. Walker and Co., Limited, Messrs. Livesey, Son and Henderson, of London, being the engineers. It should be mentioned that some preliminary work had previously been carried out by local contractors, but Messrs. Walker took over the operations at the Argentine end, where the excavations had partially collapsed, in February, 1908, and at the Chilian end, where the work was further advanced, in December of the same year. The tunnel has a headway above rail level of 18ft. 0¾in., and an extreme width of 16ft. 5in. It was found necessary to line it throughout with a layer of concrete 1ft. 7¾in. thick. Owing to the rarified nature of the air at the altitude of the tunnel it was found impossible to use steam locomotives in the constructional work—though they were tried—and compressed air engines were employed instead. The whole undertaking has been eminently successful, and it is anticipated that it will be possible to run a through train by next March.

ONE thing or another is always being done to facilitate the traffic in London, and it is now easier to get from place to place in this vast metropolis than it ever was. But much remains to be done. The increase in traffic and the advent of the motor vehicle have both rendered necessary alterations in our means of communication. The Court of Common Council recognising this, have during the month decided to adopt the Report of the Bridge House Estates Committee advocating the construction of an entirely new bridge between London and Southwark Bridges, and connecting St. Paul's-churchyard with the south bank of the Thames; and also the widening and flattening of the existing Southwark Bridge. These two works, together with the Tower Bridge and the recently widened London and Blackfriars Bridges, should provide sufficient cross-river accommodation for many years to come, but what their combined effect on the traffic passing from east to west, and *vice versâ*, would be is not easy to foretell. There are those who consider that something akin to Holborn Viaduct will have to be at no distant date constructed across Ludgate-circus. Meanwhile, another step has been taken—this time to assist foot-passengers as contrasted with vehicular traffic. We refer to the subways completed and opened for use this week at the junction of Queen Victoria-street, New Bridge-street, the Victoria Embankment, and the approach to Blackfriars Bridge. It is now no longer necessary for a pedestrian to cross the muddy streets at this point at the risk—more or less serious—of his life; but whether or not he will take advantage of this fact remains to be seen. To judge by the small popularity of similar constructions, it is by no means certain that he will do so.

THE position of the river Loire would make it one of the most valuable waterways in France if it did not suffer from the drawback of being silted up with sand. The Loire watershed comprises some of the richest country in France, which would provide a huge tonnage of traffic if only the river were kept in a narrow bed instead of being spread out in shoals and sand banks. All the towns from Nantes to Orleans are interested in the question of rendering this river suitable for traffic, and during the past month a congress has been held at Saumur to discuss a reports upon what has already been done, and what it is proposed to do, to transform the river into a vast highway from the centre of France to the Atlantic seaboard. Opinion was divided as to the way in which this undertaking should be carried out, some members of the congress arguing that it would be preferable to make a lateral canal from Nantes to Briare, where it would join the central canals. This project, however, received little support, principally on account of the cost, and it was urged that the Loire could be easily deepened sufficiently for boats of 150 tons up to Tours, and perhaps even to Orleans. The difficulty of the undertaking lies in the shifting character of the sand, but it was reported that a well-known engineer, M. Cuénot, had succeeded admirably in creating a navigable channel between the junction of the Loire and Maine and the town of Montjean. It was previously estimated that the cost of making a channel 1.20 m. deep would be 120,000f. a kilometre, but M. Cuénot obtained a depth of 1.50 m. at a cost of only 35,000f. a kilometre, this being done by making the channel banks with stakes, filled up to keep back the sand. The work is now being continued on towards Nantes, and when completed Nantes will draw traffic from about 400 kilometres of waterways, comprising the Maine, Mayence, Sarthe, and Loire. The success of this enterprise suggests the possibility, and even certainty, of creating a channel at a much lower cost than was supposed beyond the junction of the Maine up to Tours and Orleans, where it would join the canal system of central France, and it was the opinion of the Saumur Congress that the old problem of a "navigable Loire" is at length within measurable distance of solution.

FISHGUARD HARBOUR.

No. I.

THREE years ago, on the occasion of the starting by the Great Western Railway of the cross-Channel service between Fishguard Harbour and Rosslare, we published a description of the harbour works which the railway company had then constructed in Fishguard Bay as the terminus of its South Wales main line in place of Milford Haven, which for over half a century had been the most westerly point on the Great Western system in the principality.* When over fifty years ago Brunel was planning the route for the South Wales section of the Great Western Railway, he considered that the most desirable point for the western terminus of that line would be found in Fishguard Bay, but engineering difficulties supervened which for the time proved insurmountable, and Milford Haven was selected as the railway terminus.

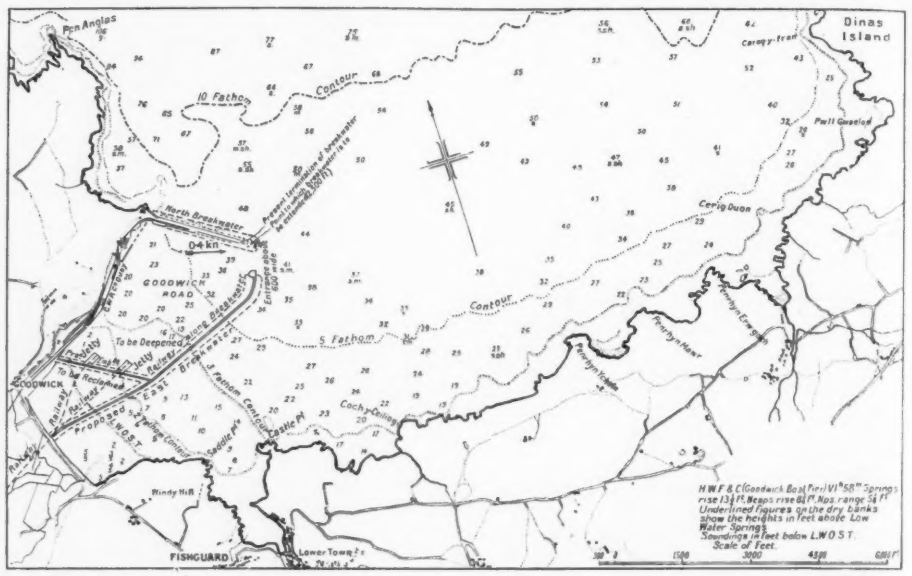


Fig. 1—CHART OF FISHGUARD BAY

The harbour works, although sufficiently advanced in the summer of 1906 to permit of the opening of the cross-Channel passenger and goods services, were far from complete; indeed, it may be said that if the hopes of the railway company for the future development of the port are realised, the works at Fishguard will be in the process of making for many years to come; and even when all the improvements and extensions now planned are realised there will be scope for still further development if the prosperity and trade of the harbour continue to increase. In the past three years a good deal of constructional work has been carried out at Fishguard, and a commencement has been made with a scheme of extension which is intended to add to the facilities of the port for dealing with transatlantic traffic on a large scale. In the present article we propose to supplement the description we have already published, and to describe in more detail the harbour works recently executed and to be constructed in the immediate future. The harbour has been constructed with the immediate object of improving the company's connections with the south and east of Ireland, but undoubtedly the directors had in view possibilities with reference to transatlantic traffic, which have at length been realised by the decision of the Cunard Company to make Fishguard a port of call for all its steamers eastward bound from New York. The Mauritania commenced the new service on the part of the Cunard Company, by calling at Fishguard on Monday, the 30th August,† and on her arrival at 1.12 p.m., three special Great Western trains, one for the mails and the other for passengers, were dispatched to Paddington, the first train arriving in London at 6 40 p.m., occupying less than 4½ hours on the journey of 261½ miles. Even better times have been accomplished on subsequent journeys. The railway company now runs special trains in connection with the Atlantic liners carrying continental passengers direct to Dover, in addition to the Paddington service. Not only do the Cunard liners now call at Fishguard on the east-bound passage, but the Booth liners, homeward bound from Brazil and Lisbon, have landed passengers and mails there since April, 1908. There is a possibility that the new arrangement of the Cunard Company will be extended in the future to include calls at Fishguard on the outward voyage. At the present time tenders are used for transferring mails and passengers from the liners, which drop anchor in the bay under the shelter of the breakwater, to the quay. When the ocean quays, to which we shall presently refer, are completed, the largest liners will be able to come alongside the quays and passenger station, rendering the use of tenders unnecessary, except perhaps in heavy weather.

A glance at the chart of Fishguard Bay, which we reproduce in Fig. 1, will show that between Pen Anglas and Dinas Island, the two bold headlands at the entrance to the bay, there is a distance of over three miles, and within the limit thus formed is a deep water area, completely protected on three sides by hills rising to a height of some 300ft. From Fishguard the distance across St. George's Channel to the Irish Coast at Rosslare is only 54 nautical miles, and its distance from New York is 2902 nautical miles as against 2957 miles to Plymouth, 3017 to Liverpool, and 3077 to Southampton.

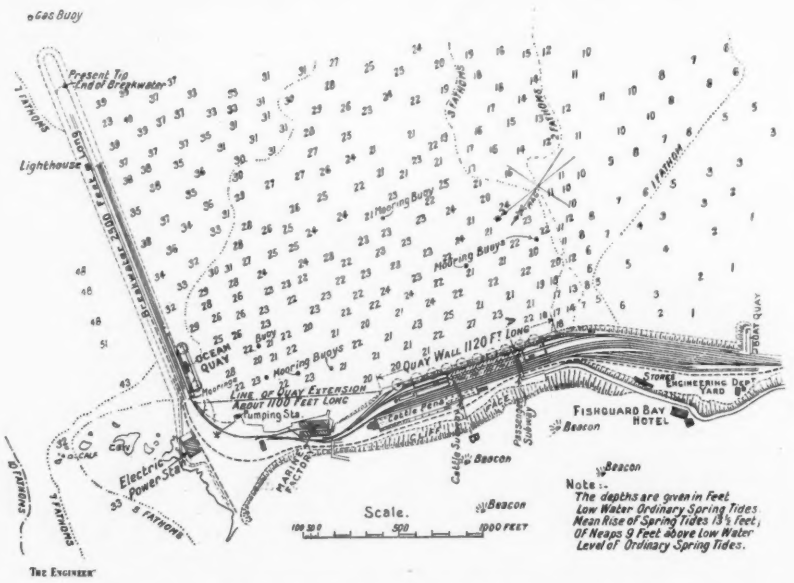


Fig. 2—PLAN OF FISHGUARD HARBOUR, OCTOBER, 1909

A glance at the chart of Fishguard Bay, which we reproduce in Fig. 1, will show that between Pen Anglas and Dinas Island, the two bold headlands at the entrance to the bay, there is a distance of over three miles, and within the limit thus formed is a deep water area, completely protected on three sides by hills rising to a height of some 300ft. From Fishguard the distance across St. George's Channel to the Irish Coast at Rosslare is only 54 nautical miles, and its distance from New York is 2902 nautical miles as against 2957 miles to Plymouth, 3017 to Liverpool, and 3077 to Southampton.

Early history of the harbour.—The earliest authenticated record of a proposal to construct harbour facilities at Fishguard dates from 1790, when a Mr. Spence made a survey of the bay and reported to the Admiralty on a

* THE ENGINEER, August 31st, 1906.

† *Vide* THE ENGINEER, September 3rd, 1909.

proposal to construct a pier at the moderate estimate of £14,785 18s. 5d. In 1845, the South Wales Railway Company, with Mr. I. K. Brunel as engineer, obtained powers to construct a line from Chepstow to Fishguard, the intention then being to run a line of steamers from Fishguard to Wexford. When, in 1851, the Great Western Railway took over the line, the works already commenced between Clarbeston Road and Fishguard were stopped, and what was then known as the Haverfordwest branch was continued to Neyland—New Milford—where suitable shelter and harbour accommodation could be obtained at a much more moderate cost than would have been possible at Fishguard. Nothing further appears to have been done in connection with the Fishguard scheme until 1893, when the Fishguard Bay Railway and Pier Company—a separate undertaking in which the Great Western Company at that date had no direct interest—obtained powers to construct a harbour there, and to connect it by railway with the Great Western system. During the succeeding five years the same company obtained powers to acquire the old Rosslare Harbour and several railway connections in Ireland, as well as further powers of constructing new lines. Another company—the North Pembrokeshire and Fishguard Railway—also came into the field with proposals, and in self-defence the directors of the Great Western Railway and the Great Southern and Western Railway of Ireland combined together to form the Fishguard and Rosslare Railways and Harbours Company with the object of acquiring the powers obtained by these two would-be competitors, and completing the works already commenced.

The required powers having been obtained in 1898, the works decided on were rapidly pushed forward on both sides of the Channel, those for which the Great Western Railway was responsible being the extension of the railway to Fishguard Harbour, the construction of harbour works, a small beginning of which had already been made, and the provision of a new double line from Clarbeston-road to Litterston, so as to avoid the use of the very steep and tortuous branch line from Clynderwen. It is interesting to note that a considerable part of the new line follows the line of the works started by Brunel sixty years ago.

The site of the harbour.—The most desirable point for the construction of the proposed harbour was on the western side of the bay, where the cliffs rise almost sheer out of deep water to a height of over 200ft. in places. The cliffs are composed of hard igneous rock—diorite—and when the works were commenced there was hardly a foothold along the entire site of the present quays and railway sidings. At first the engineers had to cart their machinery, &c., from the nearest railway point, Letterston, to the top of a hill known as Pen Cw, a height of 300ft. above sea level, whence plant and men were lowered by ropes to a point where the work of clearing and blasting could be commenced. At the date when the Great Western Railway took over the operations sufficient rock had been removed from the cliff to form a narrow strip of land on which engines, cranes, and wagons could conveniently be placed.

In brief, the original scheme, as planned by the Great Western Railway Company, and now nearing completion, comprised the following works:—(1) The formation of an area under the cliffs whereon quays, rail sidings, workshops, railway station, &c., could be constructed. This area had to be formed by blasting away the cliff and using a part of the material so obtained in reclaiming a portion of the bay seaward of the original high-water line. (2) The construction of a breakwater extending in an easterly direction from the land at Pen Cw for a distance of nearly half a mile. (3) The construction of a quay wall on the west side of the bay, with a railway station and other works. (4) The dredging of a portion of the harbour bed to a minimum depth of 20ft. below low water. Railway connection between Litterston and the harbour works was not completed until 1899; before that date the material and plant for the works had to be brought either by sea or road.

The blasting operations.—The work of cutting away the face of the cliff to provide a site for the railway terminus was naturally the first portion of the scheme to be undertaken. Over 2,000,000 tons of rock had to be removed from the cliff. A large portion of this has been utilised in the construction of the breakwater, the balance being tipped on to the bed of the sea beneath the cliff to fill in behind the quay wall. On the average, the toe line of the original cliff, which also may be taken as approximately the line both of high and low water, lies about midway between the present cliff toe and the quay face. Thus, about one-half of the present site of the terminus yard and quays, which averages 260ft. in depth, is upon the bed of the quarry, and the other half on the reclaimed sea bed. The depth of water over the site of the reclaimed area varied from 0ft. to 12ft. at low water of spring tides before the filling in commenced, and the average may be taken as about 9ft. at low water. The general surface of the reclamation is at a level of 23ft. 6in. above low water. The tidal rise at springs is 13ft. 6in. The larger blocks of rock obtained from the cliff excavation have been used in the construction of the breakwater, the smaller material, as far as practicable, being devoted to the quay filling, and sent to the stone crushers for ultimate use in concrete or as ballast. The total length of the excavated cliff is over half a mile, and the average height from quay level about 100ft.

Since the opening of the harbour in 1906 little blasting has been done on the cliff behind the quay, and a quarry has been opened out immediately to the north of the root of the breakwater at Pwll Hir, whence all the rock now required for the extension of the breakwater and for other purposes is being obtained. A view of this quarry will be found in the Supplement. In the early stages of the work the blasting of the rock was executed by direct labour employed by the railway company, but early in 1899 a contract was let to Messrs. Treglown Bros. to carry out the boring and blasting operations, a price per ton being paid for the rock actually delivered. The greater part of the site was excavated in this manner. A complete installation of compressed air Ingersoll Sergeant drills was provided for the purpose of drilling holes in the rock. A good deal of the work was done by means of drill-holes, 2in. diameter and up to 20ft. deep, the charges being 20 lb. to 50 lb. of gelagnite, of which explosive 250 tons have been used on the work. For large blasts black powder was employed, headings 5ft. × 3ft. being driven into the rock face, with cross galleries of the same dimensions, the whole forming in plan a T, of which the leg is about 40ft. in length, and each of the cross arms 40ft. The black powder was placed in two charges, one at each extremity of the cross arms, and the chambers built up; the total charge in most cases weighing 14 tons. By the firing of these mines very large quantities of rock have been brought down, in one case as much as 130,000 tons being displaced. Two of the engravings in the Supplement are from the same spot, one before and the other after the explosion of a large mine. The entrance to the heading can be seen at the base of the cliff in the first picture. Fourteen steam travelling cranes of varying capacities, from 1½ tons to 15 tons, were employed in loading the blasted rock on to wagons, blocks as large as 30 tons being tipped from wagons at the working head of the breakwater, as the Titan employed for the construction of that work, can deal with weight up to 15 tons only. Up to August, 1909, 2,620,066 tons of rock had been blasted from the cliff face and loaded into trucks. This vast quantity of material has been disposed of as follows:—

	Tons.
North breakwater (as stone tip)	1,513,099
Quay backing	791,579
Other purposes—buildings, concrete, stone plums in concrete, ballast, &c.	315,388
	2,620,066

The whole of the rock loaded was passed over a weighbridge, and a record kept of the amount loaded by each crane. An average day's load was 1500 tons, though on several days 2000 tons were passed. The ballast crusher is of the gyratory type. Rock, tipped into a large hopper, passes through the jaws, being reduced down to 2in. size, when it drops into a 70ft. elevator, which carries it to a large rotary screen. The screen takes out the ¾in. chippings and sand, allowing them to fall either into the concrete mixer or a reserve bin; the 2in. stones drop into large bins capable of holding 400 tons, under which empty ballast wagons are placed, and are filled by opening the doors in the bottom of the bins. It is thus possible to fill a train of 90 tons of ballast in twenty minutes, the rock not being "hand handled" from the time it is placed in the wagons until it is used by the packers on the line. It should be here mentioned that, in addition to the material required for the harbour works, all the ballast used on the railway works in connection was supplied by the Fishguard crushers.

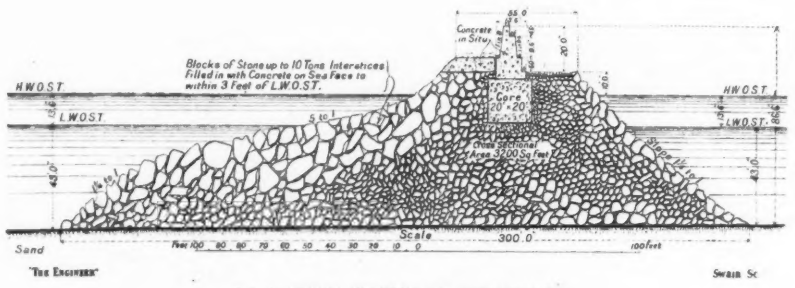

Concrete in Situ
Blocks of Stone up to 10 Tons Interstices Filled in with Concrete on Sea Face to within 3 Feet of L.W.O.S.T.
H.W.O.S.T.
L.W.O.S.T.
Core 20' × 20'
Cross Section Area 3200 Sq. Feet
Sand
Scale
300.0
Feet 100 80 60 40 20 0
100 Feet
"The Engineer"
Swain Sc

Fig. 3—CROSS SECTION OF BREAKWATER

The Breakwater.—The breakwater is of the rubble mound type, surmounted by an *in situ* concrete apron and parapet. The root of the breakwater adjoins the small rock headland of Pen Cw, whence the structure projects into the bay in a south-westerly direction. Except for a short length at the root end the breakwater is in a straight line. The depth of water on the site of the structure varied from 25ft. at low water close to the inner end to a maximum of about 46ft., the average throughout the greater part of the length being over 43ft. at low water. From the original high-water mark at the shore end to the present seaward termination the structure is 2300ft. in length, and it is now being extended to a total length of 2500ft.

The chart of the bay—Fig. 1—and the plan—Fig. 2—show the situation of the breakwater, while a typical cross section is shown in Fig. 3. The bed of the bay on the site of the breakwater is sand, which extends to a depth of over 30ft., and into which the stone mound has settled to some extent. The rubble mound is 300ft. wide at the base, over 60ft. wide at the top, and nearly 70ft. in height, the rise of tide at springs being 13ft. 6in. and the height of the causeway on the harbour face 10ft. over H.W.O.S.T. The face slopes of the mound are shown in the cross-section, that on the seaward face from half-tide down to 15ft. below low water being 1 vertical to 5 horizontal. The cross-sectional area of the structure is 3200 square feet, excluding the parapet wall, and over 650 tons of rubble are required to form one lineal foot of the structure. Stones weighing from 5 to 30 tons have been used on the sea face, smaller stones being interspersed to fill the voids between the larger blocks; on the harbour face stones of from 1 cwt. to 3 tons weight have been used. The stones on the seaward face are grouted in with concrete above the level of low water, and the mound is capped on the sea side by a concrete apron 6ft. thick, 18ft. wide on the surface, and carried down the sloping face for a distance of about 10ft. The surface of this apron is 16ft. above the level of H.W.O.S.T., or 6ft. higher than the deck level on the harbour face. Behind the concrete apron is the concrete parapet wall, built of 6 to 1 concrete and having a total height of 23ft., the height from the deck level to coping being 20ft. The height of the coping above high water is 30ft., and the total height of the breakwater is in some places as much as 90ft. above the sea bed.

The whole of the rubble mound has been tipped out from the shore, the blocks generally being allowed to take their own positions as they fell from the wagons. The average rate of progress of the breakwater between 1903 and 1906 was nearly 10ft. lineal per week.

The diagram reproduced in Fig. 4 is of considerable interest to harbour engineers, and we are enabled to reproduce it by the courtesy of Mr. Lambert Gibson, the resident engineer of the harbour works. It represents twenty-six cross-sections of the rubble mound taken at distances varying from 300ft. to 1600ft. from the shore. The sections, which are plotted to the same scale, are superposed, and in all cases represent the contour of the mound after successive gales have drawn down the slopes. The majority of the sections represent the condition of the work after several years of exposure to the sea. The designed cross section of the breakwater is plotted in dotted lines. When the construction of the breakwater had proceeded some few hundred feet from the shore and had reached deep water, it was found that the heavy waves striking and sweeping round the working head of the structure during gales from the northward caused large quantities of the smaller rubble in the unprotected face to be drawn down and driven towards the inner or lee side of the work. The effect of a northerly gale can be seen in one of the engravings in the Supplement, which is a view of the breakwater under construction, taken from the cliff at the shore end. It will be noticed that the rubble mound at the sea end has been driven towards the harbour. To minimise this wastage at the unprotected working face, a rough concrete bulkhead, or core, was constructed under the crane and wagon roads, the working face of the bulkhead being kept as far in advance as possible. This concrete core measures 20ft. by 20ft. in cross section, and is roughly rectangular; the top surface forming a foundation for the concrete parapet wall—Fig. 3. No shuttering was used in the construction of the core, but the concrete was deposited between rough dry stone walls formed by hand-packing the rubble so as to serve as side walls of a trench. The concrete was 6 to 1, with a large proportion of rock plums added. This method of construction reduced the wastage and temporary damage at the working face to a minimum, and since its adoption comparatively little of the rubble hearting

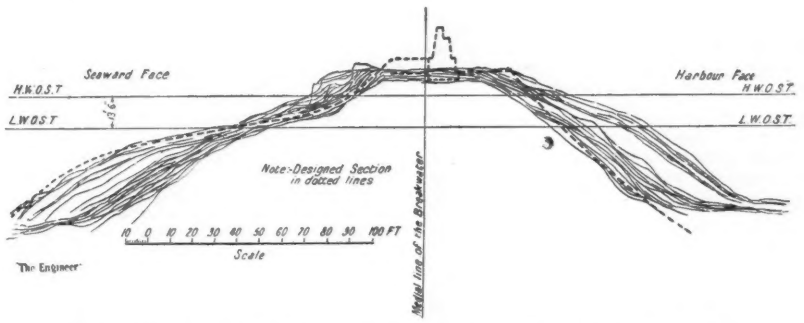


Fig. 4—TWENTY-SIX CROSS SECTIONS OF RUBBLE MOUND IN THE BREAKWATER

has been washed over to the harbour side. It is interesting to note that the concrete core or bulkhead has been constructed at an average cost of 5s. per cubic yard.

The concrete in the parapet wall and apron is 6 to 1 throughout, and the former has been built within shuttering. The apron is 6ft. thick, and of insitu concrete measuring 5 cubic yards per foot lineal of the work. A skeleton steel and iron lighthouse tower has been erected on the breakwater, some 300ft. in from the present head of the work. This tower contains a fourth order flashing dioptric light, showing one red flash every five seconds. The focal plane of the light is at an elevation of 46ft. above high water, and an electrically operated fog bell is also installed. The lighthouse will be removed to the seaward extremity of the breakwater when the work is completed. At present a bell and gas buoy, showing an occulting white light is moored about half a cable's length seaward of the end of the breakwater.

Some details of the cost of the breakwater cannot fail to be of interest. The rubble mound, exclusive of the parapet and concrete apron, but including the cost of the concrete core, has cost £78 per lineal foot of the work, or under 14s. per cubic yard. The concrete parapet and apron, which represent 11 cubic yards of concrete per lineal foot, cost approximately £5 per foot of the structure, bringing the total cost to about £83 per foot. At this rate, the total cost of the breakwater when completed to a length of 2500ft. will be something over £200,000. The prices given include the cost of blasting and rock getting, and all establishment and engineering charges.

THE GERMAN NAVAL ARCHITECTS.

No. II.*

In opening the discussion on Professor Stumpf's paper, an abstract of which we gave in our last issue, Herr Missong, of Frankfort-on-the-Main, said the diagrams of the Stumpf engine produced were rather too perfect in character, and the efficiency of nearly 100 per cent. deduced from them must remain somewhat doubtful. On the other hand, efficiencies of 85 per cent. could be obtained with ordinary compound engines. Herr Missong gave some particulars of a steam engine which he had himself patented some ten years ago, and which showed a smaller consumption per horse-power per hour, and a 30 per cent. greater utilisation of the heat than the Stumpf engine.

Director G. Henkel, of Cassel, praised above all things the simplicity of the Stumpf engine. He gave a historical sketch of its forerunners, including the Gräbner engine of 1886, the Schmidt engine of 1893, and the later developments of these of 1894 and 1896 (use of superheated steam in engines with long pistons), and finally referred to the experiments of Professor Schröder in 1894. The latter had brought down the steam consumption to 4½ kilos. per horse-power per hour, a figure which Professor Lewitzky shortly afterwards further reduced to 3.85 kilos. He welcomed the further development of the Stumpf engine, and lamented the prejudice entertained by shipowners against superheated steam. The adaptability of the system to locomotives he would like to see decided by direct investigation, so that they might know how much of the economy was due to the continuous-flow system and how much to the reduction of clearance. French designers had produced very economical compound engines by the expedient of reducing the clearance to ½ per cent. Further, he would like to know whether the tests with locomotives had been made with the breaks in the uniformity of working which occurred in practice.

Director Cornels, of Hamburg, said that a continuous-flow steam engine had been at work for two years in the Reiherstieg Yard. It was true that it was not intended for, nor used as, a marine engine, but, as a matter of fact, it did not fulfil all the requirements of the latter. Its design was simple, but the stress on the shafting, &c., occasioned by the high initial pressures, necessitated increase of the strength of such parts by about 25 per cent., and consequent additions to weight. Then, again, the condensation conditions of the marine engine were somewhat different. Further, the engine did not start well, and this defect had to be remedied by complications, which, with the consequent increase of cost, weighed heavily in the scale against the good old steam engine. Steam for auxiliary engines and for heating purposes could be taken from the main engine only when the latter was at work; it was needed, however, for the lighting engines and similar purposes when the main engine was at rest. Taken altogether, then, the advantages of the system as compared with the marine engine of to-day were not very great.

Prof. Stumpf then replied, and, in answer to Herr Missong, said that the latter's engine was a compound one, and not of the single-expansion continuous-flow type, and that it could not therefore be compared with his own. He called attention to several disadvantages attaching to the Missong engine, and remarked that, although ten years old, it had scored no successes of any consequence. With regard to the Gräbner engine referred to by Director Henkel, this was ten years old, and had no pretension to continuous flow, since the course taken by the steam was at right angles to the axis of the cylinder, while in his own engine it was parallel to the direction of motion of the piston. The Schmidt engine, on the other hand, had an outlet valve, which led the steam back to the head of the cylinder, and the principle of its action, therefore, was that of alternating flow. In reply to the questions with regard to the experiments with locomotives, Professor Stumpf said that these had not been made for show purposes, but had been conducted as far as possible under ordinary working conditions. He said the results of the experiments as given showed how much of the economy was due to the continuous-flow principle and how much to the reduction of the clearance. The drawbacks mentioned by Director Cornels in connection with the starting did not lie in the engine itself, but depended partly upon the resistance of the vessel when beginning to move. Above all, however, his experiments with locomotives engaged in shunting clearly showed that the manœuvring qualities necessary for marine work were not wanting. Further, Professor Stumpf said that he had undertaken to furnish the design for an English marine engine, and had agreed to replace it by another of first rate quality in case it should prove a failure. Before an engineer became a party to such an agreement he must be pretty sure of his ground.

Herr Sütterlin, of Hamburg, in opening the discussion on Prof. Föttinger's paper, an abstract of which we also gave last week, said he considered the work done by the author a very clever piece of modern engineering. Above all he praised the theoretic thoroughness which characterised the design and the clever use of the well-known principle involved. He wished to ask, whether in the transmission of great powers the great heat imparted to the water would not necessitate such a great amount of cooling as to cause practical difficulties. Further, he asked whether the law that the transmission of the turning moment varied with the cube of the number of the revolutions did not cease to hold good in a seaway, and when large propellers were made use of. He asked how the transformer acted when the secondary wheel on the propeller shaft was forced by the inertia of the propeller to continue its turning motion after the transformer itself had been reversed. The illustrations given showing the smallness of the space required by a turbine arrangement with transformer as compared with that of a steam engine of equal effective power seemed to him to be rather too favourable to the former.

Geh. Reg. Rat. Professor Flamm, of Charlottenburg, referred to the two points on which Professor Föttinger had laid stress in connection with the use of turbines as marine engines, viz.:—(1) Reduction of the revolutions so as to obtain a speed suitable for the propeller. (2) The avoidance of the half-speed and reversing turbines, that is to say, convenient manœuvring. With regard to the latter, he agreed with the reader of the paper, but as to the revolutions of the propeller he was, in spite of his high appreciation of the importance of the Föttinger transformer, of a different opinion. He considered that the solution of the problem of the attainment of a good efficiency, even with a high speed of revolution of the propeller, could be arrived at by suitable design of the latter. Apart from investigations in this direction made by himself, he was aware only of those of Ahlborn and Gebers. He suggested that a little assistance given to efforts in this direction might bring forth propeller designs which even at high speeds of revolution would yield somewhat the same efficiency as was attained by the introduction of the transformer. The use of this apparatus could then be avoided. The phenomenon (referred to by Professor Föttinger) of the presence of air in the propeller when working was due to the lowering of the surface of the water above the latter, in a manner which he had repeatedly established in the course of his own modest experiments.

Herr Wimplinger thought the introduction of a new member into the line of the shafting of a turbine arrange ment, which itself was specially characterised by its simplicity, was not very happy; this simplicity, and with it the reliability of the working, would, not improbably, suffer thereby. Moreover, the experimental trials with the engine of only 500 horse-power did not admit of a sufficiently definite conclusion being drawn as to the unlimited applicability of the transformer. In the case in question there had been plenty of space and weight available for the dimensioning of the transformer in the best manner for the attainment of good efficiency. Whether the same efficiency would be attained under the cramped conditions obtaining on a war vessel was very questionable. He went into the figures relating to the mean efficiency and discussed the reliability in working and cost, and came to the conclusion that the introduction of the transformer was not accompanied by any considerable advantage. This was the more to be expected that, according to the experiments of Professor Flamm, it appeared not impossible that good propeller efficiency might be attained even with high speeds of revolution. He missed a communication of the details relating to large power developments, in which large pressures and heat effects with the transformer would probably make their appearance, and produce rapid wear and tear of the wheels. He would like, further, to hear something about the vibration and corrosion to which the wheels were liable.

Prof. Föttinger then rose to reply. He said it was natural that there should be many opinions on a new apparatus like his. He had accordingly been careful not to speak in superlatives, and had taken three years to work the idea out. The somewhat scanty literature in existence about high-speed turbines in general displayed more or less bias, and he had, therefore, relied upon the experience of turbine propellers which he had himself collected. For high powers cooling would perhaps be necessary when heat that might be developed could not be utilised for the feed water; but, if so, it would be easily effected. The cooling pump need not be very large, since sea water could be used, which could flow in and out automatically. With regard to reversing, he said that if the propeller went on turning, the transformer would not be filled for a few seconds; even if it were, the diagram showed that the turning movement of the turbine, which during the manœuvre ran on in the same direction, simply increased, without, however, causing any practical difficulties. With regard to the Westinghouse reducing gear, he said that, in spite of its age, this arrangement had not yet got beyond 300 horse-power. Moreover, the toothed wheels here used in course of time became worn, and he doubted whether the system could be applied to an engine of 16,000 horse-power, such as the one for which the Vulcan Company had lately proposed to adopt his own plan. In view of his own experiments with turbine propellers above mentioned, he did not think Professor Flamm's expectations as to an increase of the revolutions of propellers without appreciable loss of effect were likely to be realised. Even the provision of a cover over the propeller to keep out the air was not a complete protection, since Ahlborn had shown that air was introduced into the water surrounding the screw, even from the bow. The introduction of a transformer produced no such complication as had on several hands been suggested; he had not, indeed, asserted that the efficiency of the whole arrangement was greater than in the case of direct driving. The advantage of his system lay in the reduction of the space and weight requirements. As to the pressures occurring in the transformer in the case of high powers he did not wish to make any definite statements; they were not, however, so high as people were inclined to suppose. As to corrosion, he had found that this took place only in one particular kind of pump, and probably depended on the presence of air, which did not get into the transformer; moreover, hot water did not take up air at all. Adverting to the remarks as to want of experience, except with the small apparatus experimented with, he pointed out that such trials had to be made on a small scale to begin with. At any rate, he could state that for greater powers the clearance resistances did not increase progressively. He criticised some statements made by Herr Sütterlin with regard to small steam and coal consumptions attained with a new vessel, which he attributed to mistakes in calculation. In conclusion, he asked that confidence might be placed in his design, so that it should not have to come to Germany as a novelty from abroad, as had so often happened before.

Herr Michenfelder's paper—see our last issue—was loudly applauded, but no discussion followed.

The discussion on Herr Gümbel's paper—see also our last issue—was opened by Professor Laas, who was pleased that an increasing number of questions of administration were being ventilated in the Schiffbautechnische Gesellschaft, and that engineers were becoming more familiar with them. He considered that the organisation should in each case lie in the hands of one man, who, it was true, would have to busy himself with a great variety of things. The sub-division into a number of single elements, proposed by Herr Gümbel, was not always feasible, and the same was the case with the judging of the costs, &c., from the work sub-divisions.

Herr Gümbel admitted that it was impossible to lay down definite rules for organisation of the kind proposed. Such rules must for various reasons adapt themselves to the circumstances of each particular case.

The first paper on the list of the second day's proceedings was a very long one by Professor Romberg, entitled "Ueber Schiffsgasmaschiene"—On Marine Gas Engines—only extracts of which were read to the meeting. After giving a general historical retrospect of the development of the gas engine, the Professor drew attention to the points which would require especial attention in marine work, viz., reliability, economy in working, small weight and space, adaptability of speed of revolution of the engine to that suitable for the propeller, and facility in reversing. Marine gas engines, he said, aimed at the driving of vessels by direct combustion of previously gasified fuel in their cylinders, a medium for the transmission of power from a source external to the latter, as in the case of the steam engine being thus avoided. This was attended with numerous advantages, comprising especially a better utilisation of the heat, the saving of the weight and space otherwise required for the boiler, an increase of the radius of action of the vessel, rapidity in getting ready for work, greater simplicity in operation, &c. Disadvantages were the high combustion pressures and temperatures of the engines, and their want of adaptability to different speeds and to reversing and similar operations.

Professor Romberg sketched the process in the four-cycle engine, consisting (1) in the sucking in of the charge; (2) of its compression; (3) of its explosion and expansion—performing work the while; and (4) of the exhaust; these operations taking place in four successive strokes of the piston. The two-cycle engine, in which the same operations are gone through in two strokes instead of four, might at first sight give promise of halving the weight and space required. It became necessary, however, in this construction to provide separate pumps in order to effect the introduction of the charge at the beginning and the exhaust at the end of the double cycle. These, again, represented weight and space, and the efficiency of the two-cycle process was less than that of the four-cycle one, so that the choice of one of these must be preceded by a careful weighing of their respective advantages and disadvantages. The mechanical complications also of the two-cycle engine were considerable. The two-cycle oil engine had some fundamental advantage over the two-cycle gas engine. The gas pump was replaced by a much smaller-sized fuel pump or gasifier, which was of a simpler nature. To judge from actual constructions, the two-cycle engine did not seem to possess any very considerable advantages over the four-cycle one. For marine work the two-cycle oil engine had considerable advantages over the two-cycle gas engine, but had no fundamental advantage over the double-acting four-cycle engine, the mechanical features of the latter being relatively simple, though still presenting difficulties which, for marine work, would have to be overcome. The double action was a necessity for the attainment of large powers. The constant-pressure process had been realised for the first time in the Diesel four-cycle oil motor. Its importance for marine work lay in its high fuel-economy, and in the possibility of the employment in it of cheap heavy kinds of oil, which were burnt without leaving any residue behind. The speed of revolution possible with this system could be varied within limits in the proportion of one to three. In suitability for marine work the engine was, in this respect, not far behind the reciprocating steam

* No. I. appeared November 26th

engine. A mixed combustion process by the French firm of Messrs. Sabathé was shortly alluded to as being one of high promise for marine work.

Professor Romberg sketched the development of the marine gas engine, and said that it had originally been designed on the lines of the stationary engines on shore, the transmission of the power from the engine to the propeller being effected by the help of belting and wheel gearing. An important improvement was subsequently effected in the adoption of vertical in place of horizontal engines. For small yachts and launches automobile motors had at first been largely adopted. It had proved to be necessary to alter the designs of these in order to adapt them for the special work that they had to perform. The mechanical aspects of these different engines were discussed at considerable length, and favourable mention was made of the American system of designing such motors with interchangeable parts, which, though carefully made, were of cheap materials and not so finished as to please the eye. Illustrations and particulars were given of a large number of actually constructed motors of different sizes and patterns.

Numerous marine gas engines were now being constructed of horse-powers ranging from 100 to 1000. These were on various systems, and for some five or six different kinds of fuel. Amongst other applications, that of the Diesel motor was being applied to submarine boats in several instances. The gas engine proper had first justified its existence in marine work after generators and purifiers had been produced that could be placed on board vessels. Generators for such purposes were now all constructed on the suction-gas principle. For such work good gas was all important. As yet this could be obtained only from expensive fuels, such as anthracite and coke. Bituminous fuels such as lignite and other inferior kinds of coal gave unsatisfactory results. Much trouble was given by tar and dirt which the gas brought with it, and which entailed frequent cleaning of the motor. Professor Romberg considered it probable that the difficulties of gas generation from cheap fuel would soon be surmounted, and said that the gas motor would then, for many purposes, be a practically useful marine engine. The application of large gas engines to marine purposes had not as yet been seriously attempted. The employment of an aggregate of small engines to give the power of a large one was accompanied by several practical difficulties. The speed of revolution would have to be considered. For large powers the small motors hitherto in existence could not be employed. Double-action cylinders of moderate length, somewhat in the style of the reciprocating steam engine, would have to be resorted to. The number of cylinders placed in juxtaposition in an engine should not exceed from four to six; otherwise the long engine became affected by the movements occurring in the hull of the vessel. Speed of revolution must be adapted to the requirements of the propeller. If twelve double-acting cylinders, arranged in pairs one above another, were combined in one engine, a unit of 8000 horse-power could be obtained, and this was sufficient for most practical purposes. The many mechanical difficulties which still existed were pretty certain to be overcome. Particulars of a considerable number of installations of motors in vessels of different kinds were given. Prof. Romberg considered that the development of the large marine gas engine would be a matter of great importance both for commercial and for war purposes.

Dr. Diesel, who rose to open the discussion on Professor Romberg's paper, confined himself to questions of an economical nature. He challenged the assertion that with the development of the oil motor industry the price of lamp oil had considerably increased. He had watched the fluctuations of the oil market prices for years. Whereas the price had formerly been M.25 to M.30 per 100 kilos. of oil, the price in Germany was now from M. 8 to M. 10 per 100 kilos., including a duty of about M. 3.6 per 100 kilos. Oil springs had in our time been discovered all over the world. By the establishment of stores of oil in enormous tanks, and by the construction of large tank vessels, the road had been smoothed for the carriage of the material to market and to the points of consumption. In addition, the circumstance that the by-products of various industries (lignite distillation, &c.), had been made use of for fuel had helped to lower the price, especially in Germany. The result of this was that Germany was independent of foreign supply, and could do without American and Russian oils, even if a considerable development of the oil motor industry should operate in swelling the consumption. For the navy, moreover, the duty of about M. 3.6 per 100 kilos. was withdrawn, so that it obtained oil at from M. 5 to M. 6., free Hamburg. Abroad, also, oil fuels could be had cheaply at all the storing stations, and these were now established all over the world in greater number than coaling stations; oil could therefore be regarded as the ideal fuel for war vessels. A great advantage which war vessels gained by the use of oil engines was the increase in the radius of action, which, with the same bunkers, became from five to six times as great as those of steam vessels. If the Russian fleet in the late war had had oil motors and oil fuel, they could have sailed to the Far East and back without stopping to bunker on the way. With weight of oil equal to that of their coal they could even have gone there and back twice over. The French submarine boats fitted with oil motors had this summer made voyages of 720 nautical miles without having to take in fresh fuel. They were now in a position at once to go over from the defensive to the offensive. The small space and weight, both of motors and fuel, rendered possible the adoption of considerably higher engine powers. Whereas, formerly, 400–600 was an exceedingly high power, they had recently gone up to 1400 H.P. In view of the foregoing it could not be denied that the oil motor must have a future for naval work.

Herr Folkers said the questionable economical conditions of the high-speed ocean liner, no less than the problems of warship construction, were pressing towards a solution of the motor question. He must strenuously oppose the mistaken view of Professor Romberg that the two-cycle motor could not hold its own against the four-cycle engine. He had investigated this question by the help of searching experiments at the Technische Hochschule in Aix-la-Chapelle, and proposed to lay the results before the Schiffbautechnische Gesellschaft at their next meetings. In actual practice, also, the mistaken notions as to the superiority of the four-cycle motor over the two-cycle had been disproved. He could not agree with the theoretical conclusion of Professor Romberg that the charging process was attended with difficulties in the two-cycle motor; neither could he admit that the utilisation of the fuel was less perfect in the two-cycle than in the four-cycle motor. Professor Junkers had conducted searching experiments on the applicability of oil motors, and especially Diesel motors, to marine work, and thereby established the fact that the other requirements of a marine engine—reliability in working, good manœuvring qualities, reversibility, and ability to run at half-speed—could up to a certain point be fulfilled. It was true that the gas engine could not work at one-tenth or one-twentieth of its full power, as a steam engine could, but it was quite possible to construct a slowly running gas engine if only the combustion were ensured. For this a high temperature in the combustion chamber was absolutely essential, and for this, again, it was necessary that the external loss of heat should not be too great. The pressure also had an influence on the transmission and loss of heat. The compression chamber must be made with the fewest possible number of valves and stuffing-boxes, small surface, and simple parts.

Director Bendemann, referring to Professor Romberg's statement that the fuel consumption of two-cycle motors was in all cases greater than that in four-cycle motors, said aeronauts would be very glad to hear by what percentage the fuel consumption of a four-cycle motor was less than that of an equivalent single two-cycle one.

In replying, Professor Romberg said that in 1880 crude oil could be had for from M. 4 to M. 5 per 100 kilos.; now, when the oil motors were being used to a still limited extent, the prices had already advanced to between M. 9 and M. 14 per 100 kilos. Crude oils could, indeed, still be obtained for M. 4 to M. 5 per 100 kilos., but as fuel for motors they were useless, unless safety of working was to be given up. The fuel consumption of a four-cycle was, as far as he was aware, always lower than that of a two-cycle motor. He could not give exact particulars or percentages. These varied in different cases. At all events, he knew of no two-cycle motor that could show a lower consumption than an equivalent four-cycle motor. For the latter about 190 gr. of oil fuel per horse-power could be taken as a minimum, while for the two-cycle motor somewhat more than 200 gr. must be reckoned.

Following Professor Romberg's paper came one from Herr Geh. Marinebaurat Tjard Schwarz, entitled "Ueber Ruderdruckmessungen u.s.w." ("On Measurements of Rudder Pressure, &c."). It contained a description of measuring apparatus designed by the late Herr Marine-oberbaurat Wellenkamp, and further developed by his successors, illustrations of which were given. In the course of experiments made with a number of war vessels it was learned that the greatest stress on a rudder was that experienced by it when a vessel turning in one direction had suddenly to make a turn in the other. Stresses on the rudder head about double those given by the Joëssel formula were in some cases registered, but it was not thought desirable to communicate definite results until fresh experiments with the recently further improved apparatus had been carried out. A specially devised photographic camera connected with recording apparatus was made use of to determine the heeling and change of trim experienced by a vessel when turning, the position of the ship with reference to the horizon being shown in a series of impressions. It was suggested that apparatus of this kind might with advantage be adopted on merchant vessels also.

"THE ROCKET'S" DRIVER.

SEVENTY-NINE years have elapsed since George Stephenson's first passenger locomotive travelled on its historic journey from Liverpool to Manchester. The man who claimed to be the engine driver of that train, and whose name was Edward Entwistle, died in the early part of last month at his home in the town of Des Moines, in Iowa. He was born at Tillsley Banks, near Manchester, on March 24th, 1815. At fourteen years of age he was apprenticed to the Duke of Bridgewater, and served in his machine shops at Manchester. At that time locomotives had been in use for about four years for hauling coal, but they had not been employed for passenger traffic, although such use was contemplated. On commencing his apprenticeship young Entwistle was immediately set to work on the construction of locomotives, and in 1830 he was elected to fill that important and responsible post of driver of George Stephenson's famous locomotive, "The Rocket." According to the story which the late Mr. Entwistle used to tell, it seems that a few days before George Stephenson was going to undertake his trial trip, the latter paid a visit to the Duke of Bridgewater's shops with the object of obtaining a suitable driver. The foreman said that he had no man that he could recommend, but added, as he pointed to Entwistle, if you can get leave to take that lad I have no doubt that he will answer your purpose. Accordingly George Stephenson saw the Duke, who gave his permission for Entwistle to become driver of "The Rocket."

It was on a Saturday, about the middle of September, 1830, when these arrangements were completed, and the date of the formal opening of the railway was fixed for the following Monday. On Sunday morning George Stephenson and his driver took "The Rocket" for a trial run. With the engine coupled to a car of gravel they ran down the track for about fifteen miles. When Monday morning came they ran "The Rocket" down to Liverpool to bring back the first passenger train on its trial trip. Great interest, it is said, prevailed among the people, and crowds stood at the dock to watch the train depart, whilst many lined the track along the entire route of 31 miles. Two flat cars upon which were mounted four ordinary stage coaches constituted the train, and it was crowded with people. It was about ten o'clock in the morning when the train started amid cheers and shouts of the spectators, and the run was made with only one stop. It was during this stop that a sad and regrettable accident occurred. According to Mr. Entwistle's version Mr. Huskisson, who was travelling on the train, saw the Duke of Wellington in another coach and the two alighted to shake hands. They stood on the track, and did not notice a gravel train approaching until the crowd shouted to them. The Duke of Wellington escaped, but Huskisson fell under the wheels. He was seriously injured and died in ten hours.

Mr. Entwistle served as driver on the train for twenty-three months, at the end of which time his nerves had become so shaken that he asked George Stephenson to allow him to discontinue the work. The road was so solid and the vibration of the engine so great, Mr. Entwistle is reported to have said, that it overtaxed his nerves. He was afraid that he would have an accident. Mr. Entwistle was very proud of the speed at which it was possible to travel in those days, and when questioned about his early experiences would take great pains to make it clear that he frequently did thirty miles in thirty minutes. In 1873 he left England

EDWARD ENTWISTLE

for America, but before that time there were many railways. The Liverpool and Manchester Railway was extended to London, thus providing rapid transit over a distance of 200 miles. Among the various stories which Mr. Entwistle was fond of relating was one pertaining to a record trip from Liverpool to London and back. It seems that, long after he had ceased to become regular driver of "The Rocket," a Mr. Francis O'Connor, who was editor of a newspaper, asked Mr. Entwistle to take him from Liverpool to London and back by special train, which he ultimately agreed to do. The train consisted of an engine and one coach. It was five o'clock in the evening before the trip was decided upon, but they were back again in Liverpool before five o'clock the next morning. It was 400 miles, and Mr. O'Connor awarded his driver four sovereigns.

Mr. Entwistle lived thirty-six years in a simple cottage in Des Moines. For sixty years he was engaged as engineer on locomotives, steamboats, and stationary engines. He always said that his mother's brother, Edward Thompson, was the first engineer on the Great Western, the first transatlantic steamer. At the age of seventy-six, Mr. Entwistle retired. In 1876 he attended the centennial exhibition at Philadelphia for the purpose of seeing his old engine, which was exhibited there. Some years ago a controversy was raging among locomotive engineers as to whether the front of the fire-box of "The Rocket" was originally vertical or inclined at an angle. At a later date, Mr. Worthington, the secretary of the Institution of Mechanical Engineers, to whom we are indebted for the above particulars, communicated with Mr. Entwistle on this point, and the reply he received was that the front of the fire-box of "The Rocket" was vertical. To have lived seventy-nine years after running the first passenger train in the history of the world was a distinction of which Mr. Entwistle was proud. This claim, however, has been objected to on more than one occasion, and doubts have been expressed as to the probability of a careful man like George Stephenson selecting a youth for such an important task as that of driving "The Rocket."

THE FOUNDERS COMPANY.—This ancient City Guild is arranging once more to hold an exhibition, which will be opened by the Lord and Lady Mayoress, in London on 7th and 8th June next year, of castings and models in metals, viz., aluminium, bronze, brass, gold, iron and silver, also of designs in wood, plaster, and any other suitable material for casting, to be competed for by founders, designers, craftsmen, apprentices and improvers, British-born subjects engaged in foundry business or its allied trades. Monetary prizes, as well as certificates and medals, will be awarded.

ROYAL AGRICULTURAL SOCIETY OF ENGLAND.—The annual general meeting of governors and members of the Royal Agricultural Society of England will be held in the Club-room, at the Royal Agricultural Hall, Islington, on Wednesday, December 8th, 1909, at three p.m., to consider the balance-sheet and the reports of the Council and of the auditors; to elect a president and trustees, vice-presidents, and auditors, to hold office until the next ensuing annual general meeting; and to take cognisance of the election of ordinary members of Council made by divisions pursuant to the by-laws.

THE BRUSSELS EXHIBITION, 1910.

THE International Exhibition which is to be opened in Brussels next April, and is to continue for at least six months, will be noteworthy in that it will be the first Exhibition for which British manufacturers have had the advantage of the assistance of the recently created Exhibitions Branch of the Board of Trade. So well has this department succeeded in its efforts that even at this early date the whole of the available space has been taken up, practically not one square foot being available.

Having regard to the excellent manner in which this new branch of the Board of Trade has worked and is working, it may not be out of place here to give a brief outline of the events which led up to its inception and of the methods which it has pursued. The department is the outcome of the report of a committee appointed by the Board of Trade in October, 1906. This committee was made up as follows:—Sir Alfred Bateman, K.C.M.G., chairman; Mr. A. Wilson Fox, C.B., of the Board of Trade; Mr. Charles A. Harris, C.B., C.M.G., of the Colonial-office; the Right Hon. Sir James Kitson, Bart.—now Lord Airedale; Mr. Algernon Law, of the Foreign-office; Mr. Malcolm Ramsey, C.B., of the Treasury; Sir Swire Smith, Sir Isidore Spielmann, and Mr. Samuel J. Waring, with Mr. U. F. Wintour as the secretary. This committee held a number of meetings, examined fifty-six witnesses, consulted various chambers of commerce, obtained reports from his Majesty's representatives abroad, and in other ways made themselves fully conversant with the then existing state of affairs as regarded exhibitions, and with the feelings of our manufacturers regarding them.

In their report, which was issued with most creditable promptitude about ten months after the appointment of the Committee, the results of the inquiry were set out clearly and succinctly. This report was divided into three parts. The first dealt with (1) "The General Effect of Exhibitions on British Arts, Industries and Trades;" (2 and 3) with "the Direct and Indirect Effect of Exhibitions on Trade;" and (4) with "the Effect of Exhibitions upon Art." In their comments on this portion of their report the Committee stated that there seemed to be little doubt as to the part which was likely to be played in all future exhibitions by the principal commercial competitors of this country. At all recent exhibitions the displays made by France, Germany, and other foreign countries have been of increasing importance, and as long as this policy was continued, the representation of British arts and industries at the more important exhibitions would remain a national necessity. It was further pointed out that little if any advantage could be expected to be derived from exhibitions at which this country was inadequately represented. There could be no profit either to the individual or to the nation as a whole in displaying inferior British exhibits by the side of the best productions of our commercial competitors. The second portion of the Report was concerned with the participation of Great Britain in past exhibitions, and Part III. contained the Committee's recommendations.

The first of these was that an improved machinery should be set up which would secure, first, a more prompt consideration of invitations to participate in exhibitions; and, secondly, a more effective representation of this country at any exhibition in which his Majesty's Government might decide to take part. To obtain these objects it was deemed essential that before everything else a continuity of organisation from exhibition to exhibition should be provided. It was accordingly advised that a permanent official should be appointed whose duty it should be to collect full information respecting past exhibitions, and to evolve a proper system for application in the future. It was further advised that instead of forming a separate Government Department for this purpose, the official in question should be attached to an existing department, preferably the Board of Trade. It was strongly insisted on that the permanent expert proposed should be the man who would take the lead in the organisation of all exhibitions. It was thought absolutely essential that he should, at an early stage of the preparations for the Exhibition, visit the site and superintend the details of organisation on the spot, and that later, when the Exhibition was opened, he should be there to control the staff and to give the exhibitors any assistance they might require, and also the benefit of his experience and advice.

It will be unnecessary to enter further into details, and we need only say that the recommendations of the Committee were acted upon in their entirety, and that the Committee's secretary, Mr. U. F. Wintour, was made the first director of the Exhibitions Branch of the Board of Trade.

In the past exhibitors have been put to great expense, not only in the preparation and transport of their goods, but in their reception and erection at the Exhibition itself. Exorbitant prices have been charged for space, as well as for necessary work done, such as the preparation of sites, the laying of foundations, &c. For the Brussels Exhibition—and it may naturally be supposed that a like course will be pursued with later exhibitions—a complete revolution has been effected. First of all, the Exhibitions Department of the Board of Trade undertook to take over a considerable area of space in commanding positions, going so far as to persuade the authorities to allocate to Great Britain and Ireland a large portion of the space which had been specially reserved for Belgium. The actual floor space thus allotted was 203,140 square feet, of which 150,640 square feet are in the Industrial Hall, and 52,500 square feet in the Machinery Hall. On referring to the accompanying plan it will be seen that practically a quarter of the Machinery Hall, which is to be devoted to all nations except Germany—that country having a machinery exhibit in its own building—has been reserved for Great Britain and Ireland.

The next step was to obtain the support of the British and Irish manufacturers, and this was, at first, found to be no easy matter. The experience of the treatment received at, and the results accruing from, past exhibitions, had been such that they were, in the majority of cases, reluctant to spend more money in this direction. As a result of the despatch of some 20,000 circulars, only seven replies were received. However, by perseverance, the Royal Commission—the Chairman of which is the Earl of Lytton—and the co-opted members of Committee, who have all worked untiringly and with praiseworthy energy, have managed to bring about a great change. By means of meetings held in various parts of the country, and personal interviews, many of both of which were attended by the Earl of Lytton himself, the objects of the new department and its methods of work have now become well known, and it has been realised that most of the disabilities which have hitherto attached to showing machinery and goods at exhibitions have been done away with.

When the advantages offered come to be considered, our readers will recognise how much this is the case. For example, one of the great deterrents to exhibitors in the past has been the impossibility of calculating beforehand how much the undertaking would cost. This objection need no longer exist. Taking the pamphlet which was issued in connection with the Brussels Exhibition, we find that the charges for space are set out in detail. These vary from 6s. to 2s. 6d. per square foot, and they included the use of all showcases—with the exception of internal fittings—stands, platforms, railings, and screens, which might be required, the storage of packing-cases and the handling of exhibitors' goods inside the Exhibition, together with the provision of unskilled labour. Providing the goods are delivered before 1st April next, the Royal Commission (*a*) take delivery of the packages at the Exhibition entrance; (*b*) unload and place them on the space allotted; (*c*) remove, store, and return empty packing-cases; and (*d*) re-load them at the close of the Exhibition, providing all unskilled labour for the purpose. These charges are, we are informed, less than half those which have been made in previous exhibitions for ground space alone.

Further than this, with a view to enabling British exhibitors to make an effective display of machinery in motion, the Royal Commission have decided to defray 50 per cent. of the charges made by the Belgian Administration for the supply of steam, gas, and electricity when used for showing machinery producing finished articles or illustrating a process of manufacture. The following are the reduced charges which will be made to exhibitors for motive power in the British Machinery Section:—

Steam at a pressure of 133 lb. per square inch	½ centime per kilogramme.
Gas	1s. 3d. per 1000 cubic feet.
Electricity (2 × 220 volts continuous)	1½d. per kilowatt-hour.

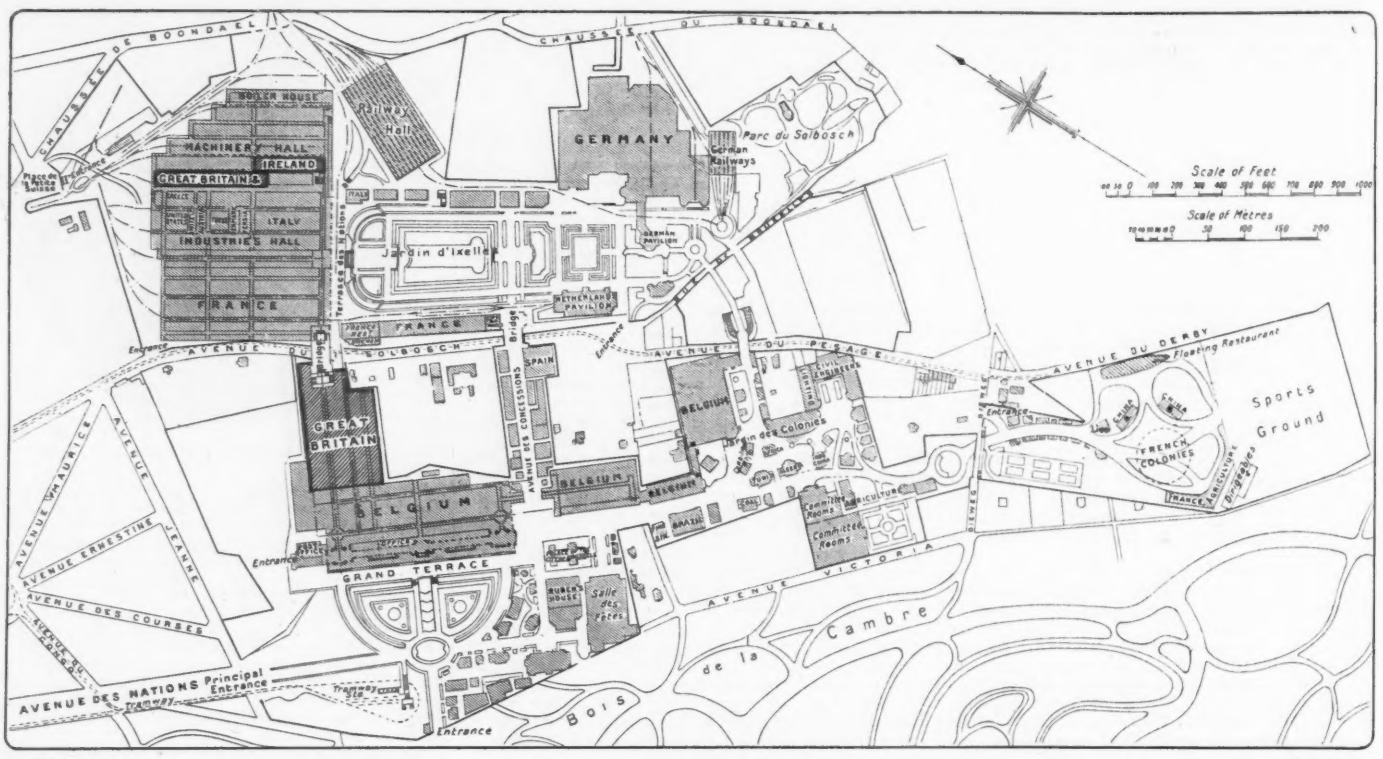
There will also be in the Machinery Hall a supply of water at a pressure of 50 lb. per square inch, for which a charge of 1s. 10½d. per 1000 gallons will be made; and there will also be a plentiful supply which can be drawn upon for condenser purposes or for illustrating the action of pumps, &c., without charge. In the Industrial Hall there are to be two services, for which the respective charges will be 1s. 8d. per 1000 gallons for domestic purposes, and 10d. per 1000 gallons for industrial purposes. Gas will be supplied for lighting in the Machinery Hall at a charge of 3s. 6d. per 1000 cubic feet, and in the Industrial Hall at 8s. 8d. per 1000 cubic feet. For electric lighting current will be available in the Industrial Hall at 110 volts continuous current, and in the Machinery Hall at 2 × 220 continuous current at a charge of 3d. per kilowatt-hour.

There will be direct railway connection with the Exhibition, and arrangements have been made by which certain important concessions are made by the various railway authorities and shipping companies. The Exhibition will be treated as a bonded warehouse, and duty will only have to be paid on those goods which are sold.

The necessary steps will be taken by the Belgian Government for the protection in Belgium of inventions capable of being patented, industrial designs or models, and trade marks shown at the Exhibition. The Exhibition has been certified as an International Exhibition, and an Order in Council has been issued by which British exhibitors will be relieved from the necessity of giving notice to the Comptroller of Patents of their intention to exhibit.

A general catalogue of the Exhibition is to be published in French, and a special catalogue of the exhibits in the British Section will be prepared in French and English. There is also under consideration the publication of a special catalogue for each separate section of British exhibits which is large enough to warrant this course being pursued.

A step has been taken which should prove of the utmost value to British exhibitors. A considerable while ago contracts were entered into by which Belgian contractors undertook to excavate ground and to construct foundations at fixed figures, which, having regard to the charges made at previous exhibitions, are remarkably reason-



"THE ENGINEER" SWAIN Sc.

PLAN OF THE BRUSSELS EXHIBITION IN 1910

able. Exhibitors requiring foundations or shafting for machinery must provide them at their own cost, but can, on sending to the Royal Commission drawings with metric measurements figured thereon, and specifications of their requirements, have estimates obtained for them, and the work carried out under the superintendence of a competent engineer employed by the Royal Commission. No charge will be made for assistance rendered in this connection, but though every care will be taken, the Royal Commission will not hold themselves responsible for any errors of construction either in measurement or material used. Crane power will be available for the erection of machinery up to 7 tons in weight, and this service will also be free of charge. Special facilities will be provided for handling heavier weights if application is made to the Commission.

It will be realised by the foregoing that every possible arrangement has been made for the convenience of exhibitors by this new branch of the Board of Trade, which deserves no stinted credit for the manner in which it has organised the British section in this the first Exhibition with which it has to deal. It has certainly shown that cause now no longer remains for many of the just complaints made regarding past exhibitions. The manufacturer can now calculate with accuracy the amount which it will cost him to exhibit. In fact, this is practically all done for him excepting that part which relates to the actual making of the exhibit and the sending out of a special agent to represent him. The strongest possible emphasis is laid upon the necessity for this, and no opportunity is lost by the Director of the Department in urging on exhibitors the fact that unless they are efficiently represented they might just as well not exhibit. The services of interpreters will be free, but the exhibitor whose agent speaks French, or, better still, French and German, will undoubtedly be far and away much better off than he who has in charge of his stand a man who only speaks English.

It would be impossible to give a list of the manufactures which will be exhibited in the British section, but we may say that these will include steam, gas, and oil engines, electrical, textile, pumping, agricultural, sugar, and woodworking machinery; air compressors, machine tools, &c.

The plan given on page 574 will show the position of the two divisions of the British section relatively to the remainder of the Exhibition, and it will be realised that Great Britain has certainly got its full share of space.

A 6000 HORSE-POWER DYNAMOMETER.

IT is now generally admitted that the highest efficiency for a marine steam turbine installation can only be obtained by running the turbine at much greater speeds than those which experience shows are most desirable from the point

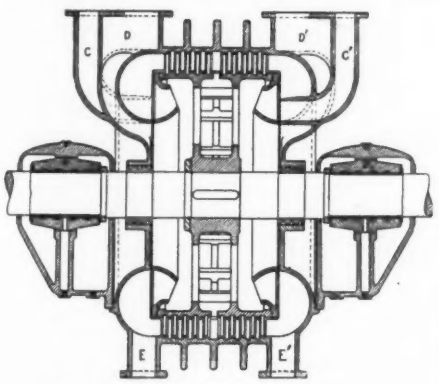


Fig. 1—SECTION OF THE DYNAMOMETER

of view of propeller efficiency. The introduction of some form of reducing gear—electrical, hydraulic, or directly mechanical—is, therefore, rendered necessary, and in that designed by Rear-Admiral George W. Melville, ex-Engineer-in-Chief United States Navy, and Mr. John

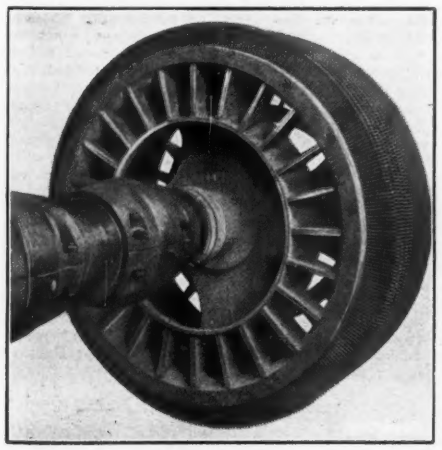


Fig. 2—THE DYNAMOMETER ROTOR

H. Macalpine, a satisfactory form, it is claimed, has been evolved. This gear is of the pinion and spur-wheel type, and has been constructed by the Westinghouse Machine Company, East Pittsburgh, Pa. As the details of its design have already become known in this country we do not here intend to enter fully into their discussion. We may, however, remark that the gear consists of two oppositely threaded pairs of helically cut spurs, reducing the speed in the ratio of five to one, while its chief claim to novelty is the arrangement employed to equalise automatically the tooth contact pressures.

In undertaking the testing of this reduction gear it was found necessary to construct a new hydraulic absorption dynamometer. Some idea of the difficulties which had to be overcome before the testing could be carried out will be understood when the magnitude of the power

Fig. 3—THE DYNAMOMETER ROTOR

transmitted through the reduction gear and absorbed in the brake is borne in mind. It was necessary to provide for the continued absorption of 6000 horse-power. To absorb one horse-power entails the generation of 2545 B.Th.U.'s per hour, and therefore provision had to be made in the apparatus designed for the carrying off of a quantity of heat equivalent to that produced by the combustion of 1200 lb. of coal per hour.

A dynamo with a water rheostat for adjusting and maintaining the load suggested itself as a solution of the problem. Besides being cumbersome and expensive, it was, however, soon seen that the high efficiency of the transmission gear would render the results obtained by this method of very doubtful accuracy, the windage and electrical losses being more or less indeterminate. It was therefore decided to remodel a form of brake used by the Westinghouse Company for testing its turbines of smaller sizes.

The design ultimately adopted will be gathered from Fig. 1. In essence, the dynamometer consists of a turbine rotor mounted on a shaft and rotating in a casing, which is provided with blades similar to those of the ordinary turbine. The motion of the rotor circulates water through the dynamometer, and as a consequence the casing tends to turn in a direction similar to that of the rotor. A radius arm forming part of the casing prevents this, and from a knowledge of the force required to hold the casing steady, the number of revolutions, and the length of the arm, it is possible to calculate the brake horse-power of the turbine. The large amount of heat generated is carried away from the dynamometer in the steam from the circulating water, vents for this purpose being provided at D D¹—Fig. 1. Figs. 2 and 3 show views of the rotor, and Fig. 6 a view of the upper half of the casing. Fig. 4 gives a developed view of a portion of the rotor surface taken parallel with the axis of the shaft. Water enters the casing through two passages C C¹—Fig. 1. From the mouths of these passages it is then thrown into the rotor drum, passing in turn through each of the ports in the end pieces, as will be understood by reference to Fig. 2. The water then travels from either side along the inner surface of the drum until it reaches the centre where ports are provided—see Fig. 3 and A, Fig. 4—conducting it to the outer surface. Immediately on leaving these ports it is met by the central row of stationary blades in the casing. These deflect it outwards in two streams, and the water thus travels back towards the outer edges of the drum, passing in turn through rows of moving and rows of fixed blades. It will be seen from Fig. 4 that the moving blades have a form similar to that of the ordinary Parsons turbine, while the stationary blades are flat, and lie parallel with the axis of the rotor

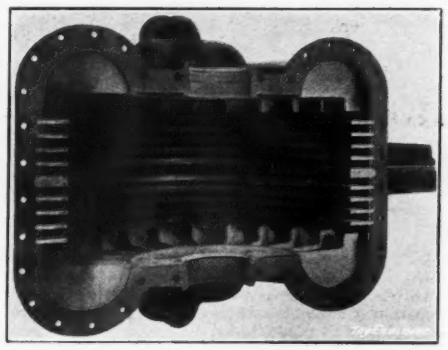


Fig. 6—UPPER HALF OF DYNAMOMETER CASING

In addition, it will be gathered from the engraving that the blades on the rotor are oppositely directed on either side of the ring of central ports.

As the water leaves the drum it possesses a certain amount of torque. This is destroyed by the baffles in the annular spaces forming part of the casing—see Fig. 6. These baffles divide the annular space into a number of distinct compartments from which the only passage available for the water to escape leads it back again into the rotor. The water is, therefore, in constant circulation along the inner surface of the drum, through the central ports, past the blades, and into the annular space, until, after having completed half a round of the casing, it reaches the lowest chamber and leaves the dynamometer

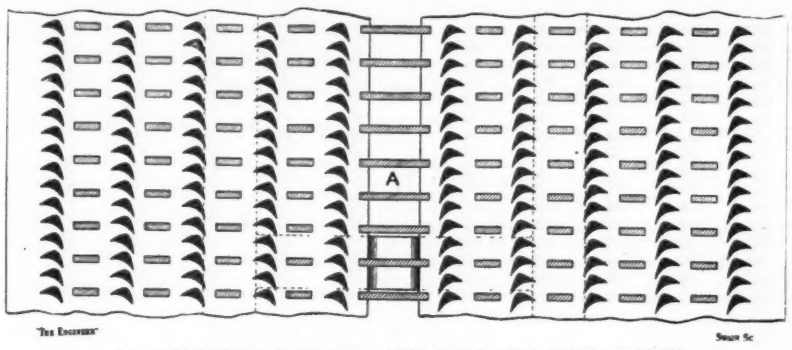


Fig. 4—DEVELOPED VIEW OF A PORTION OF THE ROTOR SURFACE

as boiling water by way of the passages E E¹. Steam formed in the interior finds an exit by the passages D D¹, which communicate with the more central parts of the drum interior where the lighter steam collects. It is not practicable to carry off all the heat generated in the form of steam, and for this reason an excess of water is circulated through the dynamometer, thus allowing some to escape as boiling water, as already explained. In addition, this affords means for regulating the braking action, a delicate control being given by altering the amount of water supplied.

To measure the force required to support the radius arm when the dynamometer is in action a portable weighbridge is employed. The forces to be dealt with and measured in the experiments for which the brake was designed were, however, not read distinctly. An I section beam with knife-edges at either end was therefore provided. One of the knife edges rested on a fixed support, the other being borne on the platform of the weighing machine. The radius arm was also given a knife-edge, which bore on a point a quarter of the total length of the beam from the fulcrum, so that the forces measured by the weighing apparatus represented a quarter of the forces at the knife-edge of the arm. Fig. 5 shows the general arrangement of the plant for testing purposes, and in this the weighing apparatus will be clearly seen.

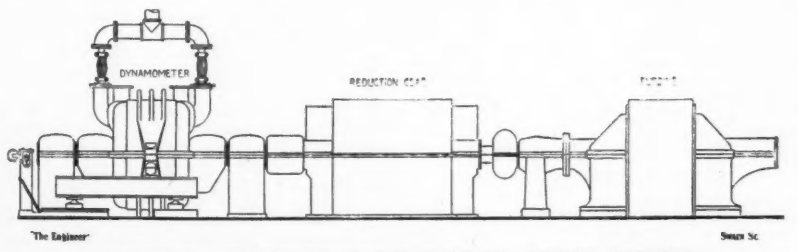


Fig. 5—GENERAL ARRANGEMENT OF THE PLANT FOR TESTING PURPOSES

To measure the efficiency of the reduction gear, it was, of course, necessary to know the input as well as the output. A series of extensive experiments was consequently carried out as a preliminary to the actual trials of the gear, and by coupling the dynamometer directly to the turbine the latter was calibrated and the horse-power developed at all loads and speeds determined. During these tests a poor vacuum was maintained, in view of the great influence which any variation in this quantity has upon the performance of the steam turbine in general. Thus a wider margin for regulation was obtained than would have been the case had the air-pump been called upon to work more nearly at its limit of capacity.

As regards steadiness, sensitiveness, capacity, and other important characteristics of a good dynamometer, we understand that this brake, unprecedented probably in its size, has given entire satisfaction, enabling an efficiency of over 98.5 per cent. to be measured with accuracy.

Testing was started on 7th September last. During the first days the readings were taken at speeds increasing up to 1500 revolutions per minute of the turbine shaft and 300 for the gear shaft. Under these circumstances the turbine was generating more than 6000 brake horse-power. On October 16th a 40 hours' endurance test was commenced.

During this trial the average conditions maintained were as follows:—

Gross weight on scale	4443.4 lb.
Dead ,, ,, ...	388 0 lb.
Net ,, ,, ...	4055.4 lb.
Speed	300 6 r.p.m.
Brake horse-power	6048

The radius arm of the dynamometer being 6½ft. and the distances between the knife-edges on the lever 18in. and $72\frac{3}{8}$in., the effective length of the radius arm becomes 26.056ft., while the constant for 1 lb. pressure on the scale and a speed of one revolution per minute is in consequence .0049612 horse-power.

As a check on the results given by the dynamometer for the efficiency of the gear, the increase in temperature which the oil bath of the gearing underwent was measured. A supply of oil under a pressure of about 10 lb. circulates through the bearings and is sprayed over the teeth of the reduction gearing. The heated oil was passed through a form of surface condenser where the rise in temperature of the oil was measured.

When the gear was transmitting 5088 horse-power it was found that 591 lb. of oil circulated per minute, though the bearings rose in temperature on an average by 9.86 deg. Fah. Taking the specific heat of this oil at 0.47, it will be seen that the friction losses as indicated by this method amount to 64.17 brake horse-power, and in consequence the efficiency of the gear is 98.75 per cent., a figure which agrees almost exactly with the result obtained from the dynamometer test.

GERMAN SHIPYARDS.

No. V.*

JOH. C. TECKLENBORG A.G., of Bremerhaven.—No. II.

We continue our description of the Tecklenborg yard at Bremerhaven. At the power-house, which supplies both the shipbuilding and engineering departments, there are four steam reciprocating engines of 300, 350, 850, and 1000 horse-power, the steam being raised in eight boilers. The corresponding dynamos develop 130, 180, 420, and 500 kilowatts respectively, continuous current of 240 volts being generated.

An extensive use is made in the works of pneumatic power, and a set of three air compressors capable of dealing with about 3000 cubic feet of air per minute has been installed. The total length of piping in connection therewith is nearly 3300 yards. The main pipe leads to a reservoir at the head of the slips, and from there underground branches are carried half-way down the sides of the slips, where they rise to the surface. At a height 11ft. 6in. above the ground pairs of rigid connections branch off again, and extend the whole length between the slips. From these the further distribution of the air takes place by means of numerous connecting pieces, first through wire-wound and then through light flexible tubes. For riveting the decks travelling air riveters and holding-on hammers are provided.

The engine shop is shown in Fig. 11, and the boiler shop in Fig. 12, page 580. Fig. 13 illustrates a shell-plate bending machine suitable for plates of all sizes, and working at a pressure of 1500 lb. per square inch. In the boiler shop an extensive use is made of the compressed air supply, caulking and tapping holes being among the many operations effected with its aid. The coppersmiths' shop measures 138ft. by 72ft., the forge 230ft. by 56ft., the foundry 262ft. by 131ft., and the new pattern and turning shop 118ft. by 105ft. With the exception of the special hydraulic machines the tools are all driven by electricity, the heavier independently, and the lighter in groups.

For the equipment of the vessels a 150-ton revolving tower crane and two travelling quay cranes of 5 tons carrying capacity and 46ft. radius are provided; while at the north end of the yard an old swing crane of 80 tons carrying capacity is still at work.

The 150-ton crane—see Figs. 10 and 15—built by the Benrather Maschinenfabrik A.-G., differs in several very important particulars from the hammer-headed cranes hitherto constructed, so that a more detailed description of it may be of interest. A slender quadrilateral pyramid-shaped column securely anchored in strong foundations bears the jib, which is connected with an outer framework that entirely surrounds the pyramidal supporting column right down to the ground. Below, this outer frame ends in a ring of I-shaped section made of plates and angles with an outer diameter of 39ft. 6in. The ring bears against four pressure rollers attached to the foot of the supporting column, so that the tilting moment of the crane is transferred to the foundations. The reduction of the foundation surface thus attained enables the crane to be set considerably nearer to the edge of the quay, and its effective radius with a given load is thus increased.

The greatest improvement, however, which was made at the instance of the shipyard, consists in the fitting of a jib crane on the outer arm of the cantilever. For this purpose the latter is arranged as a girder with a travelling crab, and the winding gear on the counter-arm is fitted between the girders. On the upper flange rails are laid for an electric swing crane which can travel along the whole length of the cantilever, that is to say, 220ft. 6in. This swing crane can transport loads ranging up to 20 tons and serves as an auxiliary hoisting apparatus in place of the appliance usually arranged on the crab, so that for loads up to 20 tons it is not necessary to set the main hoisting gear in motion. In addition, objects such as masts, which may be higher than the crane itself, can be dealt with by the auxiliary crane. The principal dimensions of the crane are as follows:—Height of the upper side of the cantilever above the ground, 140ft.; maximum carrying capacity, 150 tons at a radius of 65ft. 7in. from the centre, *i.e.*, at 46ft. from the edge of the quay; maximum radius of the large hook, 125ft. from the middle of the crane, or 105ft. from the edge of the quay, with a lifting capacity of 65 tons; greatest radius of the upper travelling crane from the turning centre, 156ft., with a maximum load of 5 tons, or 144ft. with a load of 20 tons. The greatest height of the swing crane hook at a radius of 156ft. is 167ft. above the ground.

The crab rests on four cast steel wheels, and bears five sheaves belonging to the hoisting blocks and two motors, each of 36 horse-power, for driving the travelling machinery. The hoisting gear, which takes the form of a winch, is arranged between the two main girders of the counterweight arm. The hoisting rope coming from the crab is led with ten turns round the two drums of the winch, and passes from there over a block at the back of the framework. The two winch drums are actuated by a single electro-motor through worm-wheel gearing. The hoisting speeds are 5ft. per minute with the 150-ton and 10ft. per minute with the 75-ton load. For stopping purposes there is a magnetic strap brake, while two others, controlled by a governor, prevent the permissible lowering speed from being exceeded. In addition, two sling strap brakes are provided, which, in case of emergency, can be operated from the attendant's cabin by means of a hand wheel connected with a screw spindle.

The turning machinery of the crane consists of a driving rack attached to the end of the fixed pyramid and a toothed wheel mounted on a vertical shaft, and engaging with the rack. This shaft is moved by the motor fitted in the revolving part by the aid of worm-wheel gearing. The turning, hoisting, and crab gears are worked from the operator's cabin, which is arranged at two-thirds the height of the crane; an indicating appliance shows the operator the position at any moment of the lifting hook from the centre of the crane, and at the same time gives the maximum load admissible in such a position. The driving platform for the travelling crane working on the arm is self-contained, so that the crane-man can easily keep under observation all the various movements of the lifting hook. When the small crane is at work, the large crab is run right to the middle of the crane; on the other hand, when the crab is at work, the smaller crane is moved on to the counterweight arm near the centre.

In addition to the dock referred to at the beginning of this description, the yard has two patent slips at the fishing harbour in Geestemünde for drawing up on land vessels of about 150ft. in length. These are principally used for the repair of steam trawlers.

Even in the days of wooden shipbuilding the yard of Messrs. Joh. C. Tecklenborg was noted for the excellent work turned out from it. In addition to a number of emigrant vessels, the German Polar vessel Germania and the Austrian Polar vessel Tegethoff, may rank among its noteworthy productions.

Since the change from wood to iron, the company has turned out about 160 steamers and sailing vessels, the gradually increasing dimensions and improving style of which bear witness to the steady development of the yard. In addition to about 60 steam trawlers, the fleet comprises steamers for the Norddeutscher Lloyd, the Hamburg-Amerika Line, and other large steam shipping companies. The largest vessel hitherto built in the yard is the twin-screw cargo and passenger steamer Prinz Friederich Wilhelm for the Norddeutscher-Lloyd, the dimensions of which are:—Length, 601ft.; breadth, 78ft.; and depth moulded, 41ft. 4in.; her gross register tonnage being 17,082 and her cargo carrying capacity 13,300 tons.

The yard has continued its speciality, the construction of large sailing vessels, from the days of timber to those of iron and steel, and has obtained a world-wide reputation for its four and five-masters. The yard of Joh. C. Tecklenborg has not as yet built war vessels for the German navy, but it will be clear from the description given that, as now reconstructed, it is equal to all requirements in this direction; it has, indeed, lately obtained a contract from the Imperial Navy for a gunboat, and has thus taken its place in the ranks of the warship-building establishments.

* No. IV. appeared November 19th.

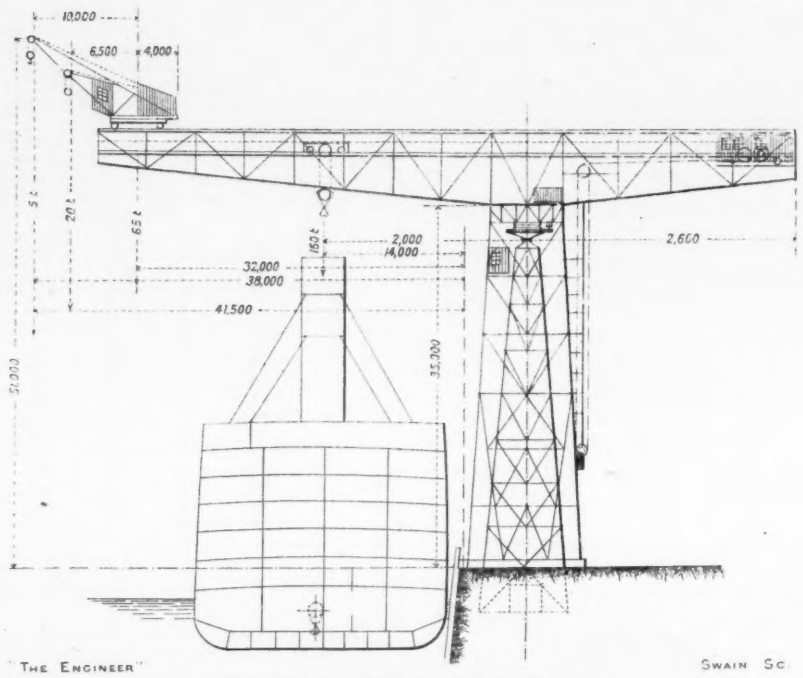


Fig. 10—150-TON REVOLVING TOWER CRANE

NEW FRENCH DREADNOUGHTS.

THE estimates of naval expenditure which are to be presented shortly to the Chamber of Deputies show that an entire change has been effected in the immediate naval policy of France since Admiral de Lapeyrère took over the work of reorganising the marine. The previous estimates, prepared by M. Alfred Picard, provided solely for an expenditure upon increasing the efficiency of the navy as it is—that is to say, the money was to be devoted to equipping the ships, replenishing stores, and improving the mechanism of the ports, so as to give a real value to the existing fleet and provide a solid nucleus for extensions later on. Admiral de Lapeyrère, however, is of the opinion that it would be a serious mistake to defer building battleships until this work of reorganisation is completed, and, having satisfied himself as to the value of the new guns and explosives during the recent trials on the Jéna, he has decided to ask for credits for the construction of two battleships, which are to be laid down in 1910. This has necessitated enormous work by the staff, since the Chamber has decided to sanction no further expenditure upon battleships until the plans are completed and the Minister is able to give exact estimates of the cost. This work, which could only be begun after the termination of the Jéna trials, will have to be completed before the debate of the naval estimates, which will take place very shortly. On account of the excellent results obtained with the guns and the new explosives, it has been found necessary to increase the weight of armour, and the displacement of the new battleships has been increased from 22,000 to 23,000 tons. Eight guns, of 305 mm., will be mounted axially in two pairs of superposed turrets, and four guns will be mounted broadside. Eighteen quick-firers, of 138 mm., will be protected by heavily armed casemates. With engines of 30,000 horse-power, the speed provided for is 21 knots. It is hoped to build the battleships in three years, so that by putting two on the stocks every year France will have nineteen battleships in 1915.

PHYSICAL SOCIETY OF LONDON.—A meeting of the Society will be held at 5 p.m. this evening at the Imperial College of Science, Imperial Institute-road, South Kensington. Agenda:—(1) J. W. Nicholson, M.A., D Sc., "The Effective Resistance and Inductance of a Helical Coil;" (2) W. A. Scoble, B.Sc., "Ductile Materials under Combined Stress;" (3) W. Makower, D Sc., and Sidney Russ, D.Sc., "The Recoil of Radium C from Radium B;" (4) C. V. Burton, D.Sc., "The Sun's Motion with respect to the Æther." Council meeting at 3.30 p.m.

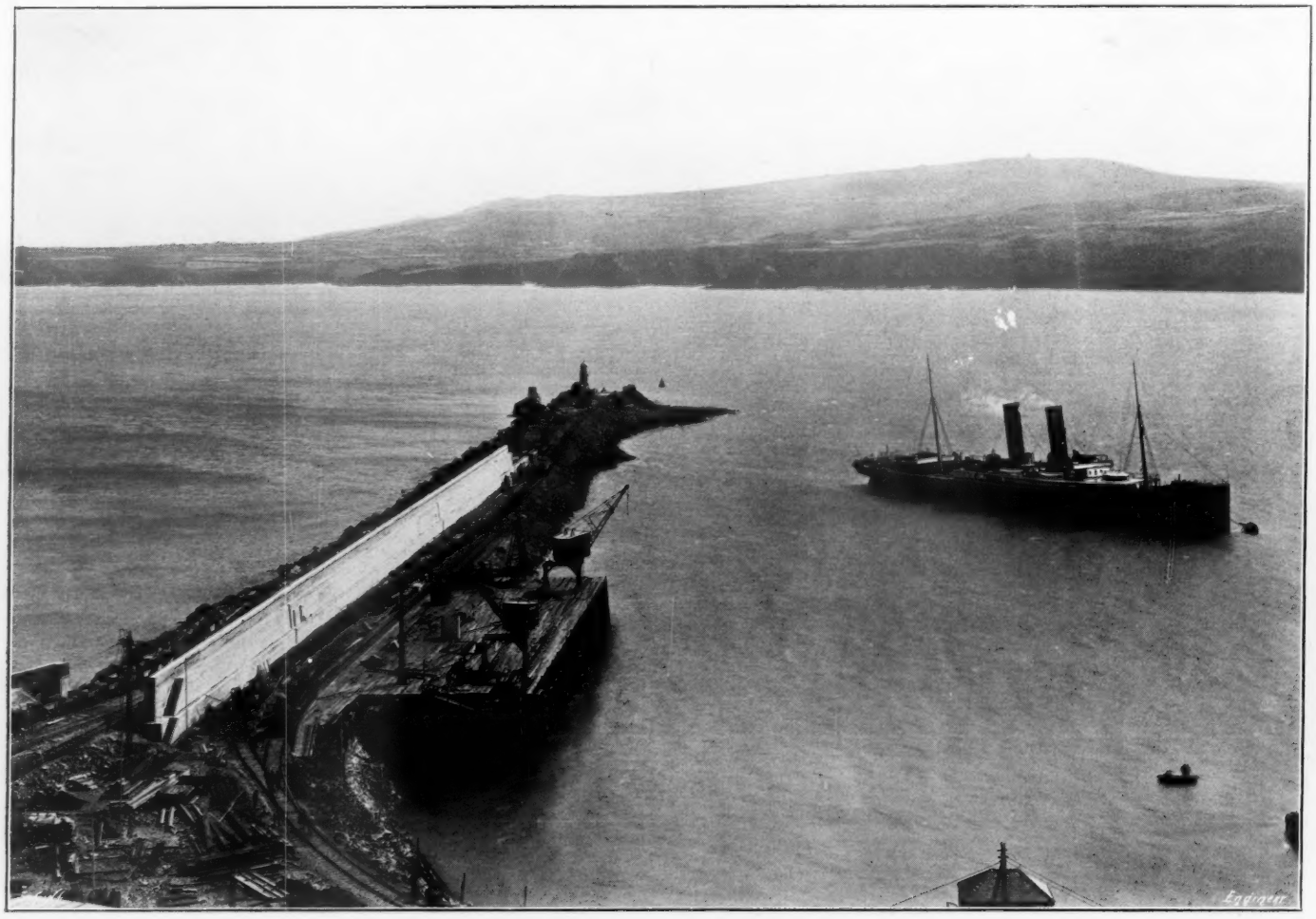
THE HARBOUR WORKS AT FISHGUARD

THE MINE BEFORE FIRING, 1st OCTOBER, 1903

THE MINE AFTER FIRING, 1st OCTOBER, 1903

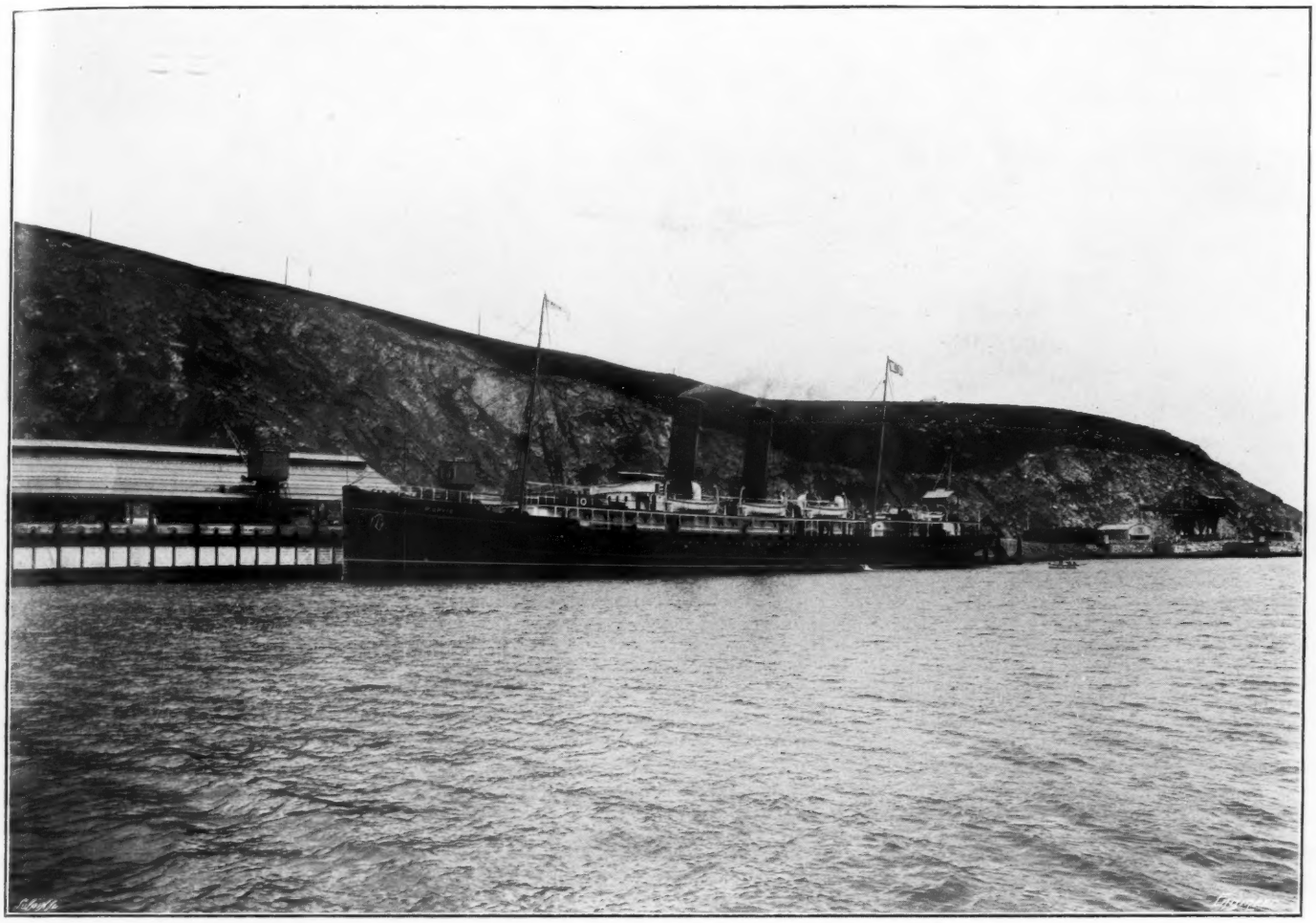
THE HARBOUR WORKS AT FISHGUARD

THE IRISH BOAT QUAY, 21st JUNE, 1906



THE OCEAN QUAY AND NORTH BREAKWATER, SEPTEMBER, 1908

THE HARBOUR WORKS AT FISHGUARD



THE IRISH BOAT QUAY FROM THE HARBOUR, 21st AUGUST, 1906

GENERAL VIEW OF HARBOUR, JUNE, 1909

THE HARBOUR WORKS AT FISHGUARD

FISHGUARD HARBOUR VILLAGE, 10th APRIL, 1908

THE PWLL HIR QUARRIES, 8th JULY, 1909

OLD AND NEW GASHOLDERS AT GATESHEAD

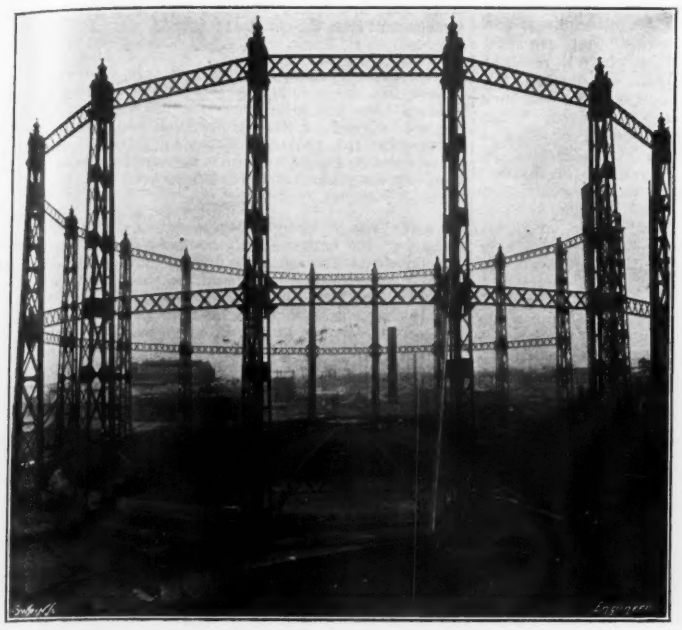


Fig. 1—THE ABANDONED GASHOLDER, 1,750,000 CUBIC FEET CAPACITY

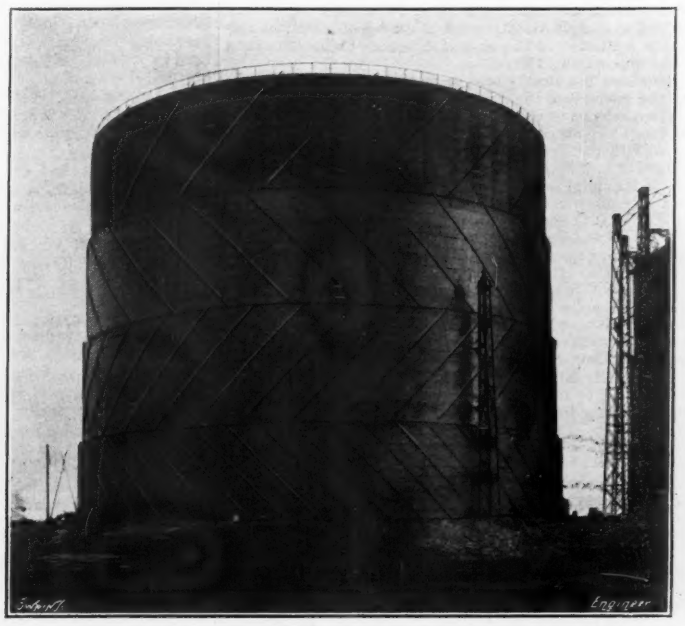


Fig. 2—THE NEW GASHOLDER, 3,500,000 CUBIC FEET CAPACITY

A LARGE COLUMNLESS GASHOLDER.

AN interesting piece of work is represented in the dismantling at the Redheugh Works of the Newcastle and Gateshead Gas Company of a column-guided gasholder, having a capacity of 1½ million cubic feet, and the construction in the same tank of a spiral-guided gasholder, with storage for 3½ million cubic feet. The column-guided gasholder was built about twenty-seven years ago from the designs of the late Mr. V. Wyatt, and its inner lift was 169ft. 4½in. in diameter by 36ft. 3in. in depth, whilst the outer lift was 172ft. 4½in. by 36ft. 7in. The four lifts of the

Fig. 3—VIEW SHOWING SOME OF THE CARRIAGES

new spiral-guided holder are each 36ft. 7in. in depth, and the following are the diameters:—Inner lift 164ft., second lift 167ft., third lift 170ft., and outer lift 173ft. The tank, 175ft. 4in. in diameter by 38ft. deep, is in excellent condition, having a concrete bottom and cement-faced dumpling, whilst the wall is of concrete, with an inside brick lining 9in. thick, built in cement, and between the brickwork and concrete are 2in. of pitch. The radial main bars of the roof

Fig. 4—EXTENDED SIDE PLATES ON CROWN AND TOP

framing of the holder were of the lattice type braced with circumferential lattice girders, and this framing is now fixed on stanchions in the tank to support the crown when the holder is at rest.

The old holder was guided by eighteen standards of the box type, rectangular in shape, and braced together by two rows of lattice girders, while the members were connected by strong steel angle and tee lattice bracing, secured by covering plates. Sixteen of these have been removed, the bed-plates being used for supporting tank carriages and rollers. These old bed-plates, excepting the two which were allowed to remain for the purpose of supporting the anti-freezing apparatus, have been filled with cement concrete and capped with plates. As previously stated, the old roof framing, with certain additions and modifications, has been utilised for carrying the crown when at rest, and is supported by stanchions. The principal members were shortened in order to admit of the extra lifts introduced, and also the inlet and outlet pipes, which are 3ft. in diameter, and have been

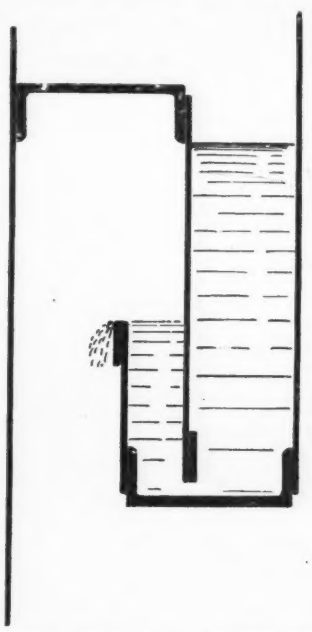


Fig. 5—HYDRAULIC CUPS AND DIPS

altered to meet the extra depth and smaller diameter of the inner lift.

As the new holder is the largest which has yet been erected on the spiral-guided system, some particulars of the constructional details may be of interest. The top curbs—Fig. 6—of the inner lift comprise a 6in. by 6in. by ⅜in. steel angle ring

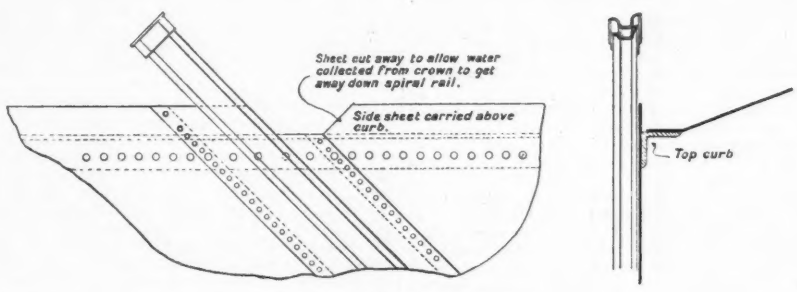


Fig. 6—DETAILS OF TOP CURBS

at the joint between the crown plates and the side plates, and a further circumferential girder is secured to the outer row of crown plates some little distance from the outer edge, this girder being formed of two 4½in. by 3½in. steel angles with a ⅜in. web. The thirty-six vertical stays are splayed out at the upper end and secured to this inner curb, the stays being of the lattice girder type with ⅜in. thick solid web plates at the upper end and foot, while the latter is further strengthened by a lower curb running around the inside of these vertical stays formed of 8in. by 3½in. channel steel. These vertical stays are 18in. wide at the foot parallel to within 5ft. 9in. of the upper end and increasing to about 3ft. 9in. wide at the top, and are secured to the inner curb as before explained, and also to the side plates and outer row of top plates by rivets. The plating for the sides is ½in. thick at the top, with butt joints, having cover-plates ⅜in. thick. The lower row of the side plates is ⅜in. thick, the rows next the foregoing are ¼in. thick, and the remaining side sheets are all No. 10 B.W.G. Worked into these sheets are the ⅜in. spiral plates, to which are riveted the spiral guides. For the crown, the outer row next to the top curb is ⅜in.

Fig. 7—FRAMEWORK OF CROWN

thick, having butt joints with 9in. by ⅜in. cover-plates. The adjoining row is ⅜in. thick, also butt-jointed with 7in. by ¼in. cover-plates. The next row is $\frac{3}{16}$in. thick, the joints being of the ordinary lap type. The remaining rows, excepting that adjoining the centre plate, are No. 10 B.W.G. There are the usual manholes, air pipes, blow-offs, &c., and a substantial handrail round the edge of the crown, supported by strong cast iron standards.

Concrete piers were formed upon the old dumpling of the tank and carried up sufficiently high to form a square footing for these stanchions to rest upon. The second lift has thirty-six vertical stays, formed of 8in. by 3½in. steel channel, and the top row of side plates is ⅜in. thick, the next row ½in. thick, the intermediate rows No. 10 B.W.G. The hydraulic cups and dips—Fig. 5—are each 21in. deep by 11in. wide. The vertical stays and sheets of the third lift are practically a repetition of those of the second one. The outer lift, however, has thirty-six vertical stays of 8in. by 8½in. channel steel, and the bottom curves are formed of two 8in. by 3in.

by 20 lb. steel channels, having the usual butt joints with §in. thick covers, and these are riveted back to back and to the lower row of side plates. The side sheets of this lift are §in., ¾in., and No. 10 B.W.G. thick. As the difference in the diameters of the several lifts is 3ft., there is a space of 18in. between the edge of one lift and the plates of the next lift, and this extra width permits of the top of each lift being used as a platform. The normal difference in the diameters of the lifts is about 12in.

Reference has already been made to the method of attaching the carriages to the tank, and some particulars may now be given relative to the rollers, of which there are 54 pairs on the tank, 36 pairs on the third lift, 27 pairs on the second lift, and 18 pairs on the inner lift. These rollers allow for expansion and contraction, and although they have a firm grip on the spiral rails of the lift, they respond freely to any expansion due to climatic conditions. They have two flanges which gear with and revolve along the front edges of the steel spiral rails, and they have an extension at the back to give a wider bearing upon the fixed axles, where they are applied to the inner lifts. Upon this extension a hexagon is formed so that these rollers may be turned upon their bearings with a spanner in order that the oil holes may be turned to the vertical position when necessary. This speciality, however, is not required on the rollers for the outer lift. These are fixed upon their axles, which have long bearings revolving in specially designed carriages. In order to avoid the disfigurement caused by the unequal washing over the surface of rain-water running from the top of the holder and overflowing from the cups, the upper rows of side plates on all four lifts have been carried about 3in. above the curb and a gutter thus formed around the outer edge of the lifts. Near to the upper end of each spiral rail there is a curved opening in the projecting part of the top plates, and this causes the spiral rails to be used as a medium of travel for the water between the cups of the lifts until it reaches the tank.

It has been found that the use of anti-freezers in very cold weather creates a difficulty. The condensed steam used for keeping the cups and dips free from ice causes an excess of water, which usually overflows the sides of the gasholder and there forms solid ice, and to such an extent has this been the case in Canada that the ice thus formed on the outside of gasometers has prevented one lift from entering the next. This trouble has been entirely overcome by the arrangement which has been adopted in the new gasholder at Redheugh. A continuous ladder gives access from the ground to the crown of the holder, with the lifts in any position. Although the sections of the ladder are in very different positions when the holder is at rest, the ladders come into line as soon as a lift gears with that which follows it, and when the holder is fully inflated there is perfect ladder alignment.

The new gasholder is situated on an exposed portion of the south side of the river Tyne, immediately opposite the Elswick Works, and is 15ft. above the level of the adjoining ground, and whilst fully inflated, it has been exposed to a wind pressure of no less than 52 miles per hour, and to 22 deg. of frost. The old tank was dismantled and the new work erected in its place within a period of ten months. The column-guided gasholder was originally erected at a cost of £11,603, and the estimate for the same work at the present time was £15,211. The cost of the whole of the work involved in the reconstruction of the holder and the erection of the spiral-guided holder of twice the capacity was £18,000. The contractors for the work were R. and J. Dempster, Limited, of Manchester, and the designs were prepared by and the work carried out under the direction of Mr. W. Doig Gibb, the chief engineer of the Newcastle and Gateshead Gas Company, who has since been appointed chief engineer of the South Metropolitan Gas Company, London. The engravings herewith show the new gasholder and that which it has displaced, and three views of different parts of the new holder taken during construction.

THE LAUNCH OF THE SECOND-CLASS CRUISER NEWCASTLE.

On Thursday, November 25th, the second-class cruiser Newcastle was successfully launched from the Elswick shipyard of Sir W. G. Armstrong, Whitworth and Co., Limited, the naming ceremony being performed by Lady Jellicoe, the wife of Rear-Admiral Sir J. R. Jellicoe. The Newcastle is one of the group of the five vessels of the protected cruiser type included in the Naval Programme for 1909-10, and she has a length of 430ft., a breadth of 47ft., and 4800 tons displacement at load draught. The machinery is being furnished by the Wallsend Slipway and Engineering Company, Limited, and consists of turbine machinery of 22,000 horse-power, calculated to give a speed of 25 knots. Following the launching ceremony, the company of invited guests adjourned to the mould loft, where refreshments were served, and in the course of an interesting speech Sir Andrew Noble recalled the fact that the first ship to bear the name of Newcastle was built at Ratcliffe in 1653, and served under Blake, taking part in two of the greatest feats of arms, the bombardment of Tunis and burning of the Corsair fleet, and in the destruction of the Spanish treasure fleet at Santa Cruz, Teneriffe.

In addition to the interest attaching to the Newcastle, which had just been launched, on account of her being named after the city which gave her birth, there was another very exceptional, if not unique, feature in connection with the vessel and launch, which was worthy of special notice. As would have been observed, the vessel left the ways having her four funnels erected in position. The actual building of the vessel was commenced about the end of April last, and so rapid had been the progress made, both on the hull and machinery work, that they had been enabled to place on board and fix in position before the launch the whole of the boilers, condensers, wing turbines and other auxiliary machinery, while the whole of the machinery and boiler-room bulkheads and the protective deck above the machinery and boiler compartments had been finally riveted up, completed and water tested. Only two heavy weights—namely, the main turbines—remained to be lifted on board, and this operation was to be carried out on the following day. Thus, although the Newcastle was the last but one of her group to take the water, it was more than probable that at the present time she was further advanced and nearer readiness for trials than any of the other four vessels. So far as he knew, no vessel of the size or class of the Newcastle had hitherto been launched in such a condition, and they might therefore fairly claim to have established a record in her case.

OBITUARY.

GEORGE HEPBURN.

The death is announced as having taken place on the 30th ult. of Mr. George Hepburn, naval architect and consulting engineer, of Liverpool. Mr. Hepburn was born in 1841 at Cults, in Aberdeenshire, where he received his early education, afterwards passing through the course at the local Mechanics' Institute. He was then apprenticed to his father, who was a millwright. When he had completed his time he served for three years as apprentice to the Clyde firm of Randolph Elder and Co. While there he had charge of the erection of the first two compound marine engines made on the two-cylinder principle. These engines were fitted in the steamer Murillo, owned by Robert MacAndrew and Co., of Liverpool, and in 1863 Mr. Hepburn was made chief engineer of this steamer, having as his second in command Mr. R. W. Watson, who at present holds the post of superintendent engineer to the MacAndrew firm.

After sailing in this vessel for two years he was made by Messrs. MacAndrew manager of their liquorice works at Frodsham, but in 1866, when this business was transferred to the United States, he was made superintending engineer in Liverpool to the firm. This position he held for eleven years, during which time he designed thirty-three vessels for his employers.

In 1877 he started on his own account as naval architect and consulting engineer. He was made consulting engineer to the firms of Phelp Brothers, Hatton and Cookson, Job Brothers, John Glynn and Sons, and Taylor, Cameron and Co. amongst others, and designed the vessels of all these firms. He also had an extensive business as arbitrator and scientific witness, and was associated in the latter capacity with the trials connected with the Austral, City of Paris, Delpho, and Kimberley. He was a member of the Institute of Naval Architects and of the Institute of Marine Engineers, and was the inventor of numerous engineering equipments.

GEORGE THOMPSON.

We have to record with regret the death of Mr. George Thomson, who died at Waterloo, Liverpool, on Tuesday evening. Mr. Thompson since 1903 was associated with the engineers' department of the Cunard Steamship Company, and in 1904 succeeded Mr. Little in the position of superintendent engineer. In the fulfilment of the duties attached to this post he had much to do with the engineering features of the Cunard Company's turbine steamers Carmania, Lusitania, and Mauretania. Although only forty-two years of age at his death, Mr. Thompson had had a wide experience of his profession, and had always been a strenuous but modest and retiring worker. Commencing his training as an apprentice engineer in the works of Harland and Wolff, Limited, at Belfast, his experience included that of a sea-going engineer on the Lord Line among others. Later, he returned to Harland and Wolff's, and at first held a position in the drawing-office, being appointed afterwards to the responsible post of works manager. From this position he left Belfast in June, 1903, to join the Cunard Company's staff. Some idea of the magnitude of the duties which he so ably executed can be gathered by noting that the company's engineering staff ashore and afloat number about 4500 men. By all those who knew him Mr. Thompson was highly respected, and amongst the engineers of his district he was regarded as possessing the greatest ability in his profession and knowledge of the many different types of machines with which his position brought him into touch.

DOCKYARD NOTES.

A curious correspondence is going on in our contemporary *Le Yacht* between the director of the Fiat-San-Giorgio and Monsieur Laubeuf, the well-known French constructor, on the subject as to whether the Hvalen or the Papin holds the world's record for cruising ability. The Hvalen, which was built for Sweden, was designed by Signor Laurenti. She left Spezia on the 31st July last and arrived at Stockholm on the 2nd October—a total distance of 3600 miles in 64 days, going *via* the Kiel Canal. This averages 60 miles a day.

M. Laubeuf draws attention to the cruise of the submarine Papin, designed by himself, which ran from Cherbourg to Bizerta, a distance of 2200 miles, in 21 days, an average of a little over 100 miles a day. M. Laubeuf claims that this represents a record rather than the performance of the Hvalen, on the grounds that the rate covered per diem is more important than the overall distance. This may or may not be so, but there is no question that the Hvalen's record is an extremely fine one, and that the Fiat-San-Giorgio Company may be regarded as producing first-class submarines.

Considerable doubt exists as to what big ship is to be added to the Greek navy. It was stated with a good deal of authority lately that one of the Pisa class was to be purchased out of the fortune left by a deceased millionaire to the Greek navy for naval augmentation. But reports in the Levant all speak of a battleship as having been determined upon. Greece is in the peculiar position of being fairly likely to be at war with Turkey at any time. On the occasion of the last war the Turkish fleet did nothing worse than astonish the world by the fact that it moved, after lying in one place for 30 years. The principal record of the Greek navy was, however, very little better. The ships certainly cruised further than the Turkish ships did, but the navy proved itself singularly inefficient. Since then the Turkish fleet has been reorganised, and the situation in Greece is necessarily affected thereby.

A new system of funnel marking has been adopted for the British Navy. In future, regardless of whether they are flagships or no, ships will carry funnel marking—not by the old system of seniority, but purely and simply following their alphabetical order in their classes. Thus, for example, in the Bellerophon class, the nameship, whether a flagship or not, will always have unmarked funnels. The Superb will carry one band, and the Téméraire, on the principle that T comes after S, will carry two. This is a far more sensible arrangement than the old one.

It is curious commentary on how they work things in France, that the trials arranged for long range firing against the Iéna have had to be put off for the time being owing to the sum allowed for these experiments having been already exhausted. Apparently the Minister of Marine had already come down to Toulon to witness the experiments when the discovery was made that no funds were available.

Very little is really known about the new battleship Orion and the cruiser Lion, the keels of which were laid respectively at Portsmouth and Devonport on Monday last. It is rumoured, however, that the Orion will be 545ft. long between perpendiculars. As for the Lion, rumour has it that she will be a Dreadnought in an Indefatigable setting—that is to say, that she will carry ten 12in. guns arranged as in the Dreadnought, or with possibly the two amidship turrets écheloned. This last is perhaps somewhat doubtful. Naval ideas in England seem rather to be running on American lines, with all guns on the centre line, which, when all is said and done, is an arrangement hard to beat for practical purposes, however much more attractive other designs may look on paper.

The official full-speed trial of the Brazilian destroyer Alagoas took place on Friday last, the 26th inst., on the Skelmorlie measured mile at the mouth of the Clyde during boisterous weather, and the contract speed of 27 knots carrying a load of 100 tons was easily obtained. The trial was under the supervision of Captain A. Rosauro de Almaida and Captain Bartholomeo Francisco de Souza e Silva, these gentlemen representing the Naval and Engineering Departments of the Brazilian Naval Commission in Europe. The Alagoas is the seventh of the ten destroyers ordered from Yarrow and Co. by the Brazilian Government, the Para, Piauhy, Amazonas, Matto-Grosso, Rio Grande do Norte, and Parahyba being already in commission.

A NEW ALUMINIUM SOLDER.

An aluminium solder has been brought to our notice which appears to answer the purpose for which it is intended in an efficient manner. Joints made with it are claimed to possess that important property of retaining their strength over an unlimited period. The solder is being put upon the market by the Aluminium Patent Non-flux Solder Company, of 10, Camomile-street, London, E.C. We recently attended a demonstration at which joints were made in aluminium strips with rapidity and ease.

Briefly, the method of using the solder resembles very closely the procedure adopted when soldering other metals, except that a steel "bit" is used instead of a copper one, and that the process does not involve the employment of a flux. The type of soldering iron used by the firm, whilst somewhat crude, consisting as it does of a three-cornered file ground flat on its three sides, appears to do the work well, and we should say—although we have not actually tried to make a joint ourselves—that the art of using the solder is easily acquired. Although the appearance of the solder is apt to convey the impression that it is hard, and that its melting point is high, the reverse is the case, for it melts almost as readily as the common tinsmith's material. We are informed that it contains no aluminium whatever, nor anything which will oxidise under the influence of the atmosphere.

Many articles which have been repaired by this process were brought to our notice, and the repairs appeared to be perfectly good and sound. Those of our electrical readers who have experienced difficulty in sweating on the lugs on aluminium conductors may be interested to know that the firm has carried out experiments in this direction, and with the aid of a simple soldering iron such as that described above has succeeded in performing this operation with great ease. We have examined samples of work of this kind, and we should say—although, of course, to be in a position to state definitely it would be necessary to measure the drop in potential over the joint, which we have not had the opportunity of doing—that the electrical connection was very perfect. The firm believes in using the steel soldering iron whenever possible, but for repairing most castings a blow-pipe is necessary.

Sir Christopher Furness and Trade Prospects.—In the course of his speech to the shareholders of Richardsons, Westgarth and Co., Limited, at their ninth ordinary general meeting, held at Hartlepool, on Saturday last, Sir Christopher Furness—chairman of the directorate—said: It must be a source of satisfaction to them all to observe that so far as one could gather the worst was really over, and that there were indications of a gradual return, not to anything in the nature of a boom, but to at least normal industrial conditions, as soon as the present unfortunate political unrest gave place to calmer times. It was necessary for them, however, to realise that a new order of things was beginning to prevail, and that, whether trade be good or bad, they would have to take seriously into account an ever-expanding increase in foreign competition. The arena of the conflict also was enlarged year by year, and if British manufacturers were to hold their own some form of intelligent co-operation amongst themselves will have to come into being, and thus to avoid the existing lamentable wastage in the country. For example, the working and establishment expenses alone of the various mercantile marine engine builders of that coast aggregate fully £300,000 per annum, and in no other leading industrial country in the world would such a large expenditure be tolerated, without some collective effort being made to minimise it. They might doubtless remember that already something had been attempted in this direction, and although in the meantime success is lacking, he was convinced that ere long circumstances would so force their hands as to bring about an intelligent fusion of interests, an arrangement whereby their country would be able to produce at a more natural level of cost than existed to-day. Speaking generally, it seemed to him that what the industries of the country most of all needed was a period of quiet convalescence, freedom from legislative disturbance, a cessation of the harassment which labour troubles involve, and, in short, a period of quiet wherein they might be free to travel calmly and steadfastly on the road to a healthy recovery and renewal of strength.

RAILWAY MATTERS.

THE piercing of the Trans-Andine Railway tunnel at the summit of the Cordilleras was completed on November 27th, and the Chilian and Argentine sections were joined with complete success.

THE *Journal de St. Pétersbourg* of 3rd November states that the Russian Government have authorised the construction of the following lines:—Kieff to Balta *vid* Vassilkoff and Kristinovka; Ouman to Nicolaeff *vid* Olviopol and Voznesensk. The length of these lines will be, in all, about 400 miles.

THE *Journal de St. Pétersbourg* of 11th November announces that a company, with a capital of about £4,917,000, is in process of formation to construct a new railway from St. Petersburg to Helsingfors. Following the coast, this line will reduce by 15 hours the journey between the capital and the extreme western point of Finland.

IN 1898, states a contemporary, only some 40 electric tramways were in existence, with a capital of approximately £24,000,000, while from the latest returns there are at present 305 undertakings in the United Kingdom, with a capital of £68,199,918, the gross receipts being £12,439,625. The total number of passengers carried per annum amounts to the large total of 2,625,532,895.

THE replacing of timber structures with those of steel or concrete on the main line of the Northern Pacific Railway, between St. Paul and Livingston, Mont., states an American contemporary, will probably be completed by the end of 1911. A plant has been erected at Gleadive, Mont., for making concrete piles and girders which are to supersede wood in the present pile bridges, except in cases where steel construction is used.

IN the House of Commons recently, replying to Mr. Rees, Colonel Seely (Under-Secretary to the Colonial Office) said that the question of constructing a short line of railway from Jinja, on the Victoria Nyanza, to a place on the Nile some 40 miles below the Ripon Falls, was under consideration, but it had not yet reached the stage at which a definite decision could be given in the matter. That was the only extension contemplated at present.

THE Erie Railway, in America, has provided one car in some of its suburban trains for those who object to the steam heat and stuffy atmosphere of the regular cars. The cars carry signs reading "Fresh Air," and are started out with the doors, ventilators and alternate side windows wide open. Any person riding in these cars is privileged to close the window next to him, but has no right to insist on the closure of other ventilation openings. The will of the majority of those who ride in the cars will control the turning on of the steam, which may be wanted in very cold weather. Those who find the cars too cold can always move to other cars in the trains. This, it is considered, is a novel but sensible way of solving the vexatious problem of heating and ventilating cars in winter.

IN his presidential address before the Institution of Engineers and Shipbuilders in Scotland, Mr. C. P. Hogg did not speak enthusiastically of railway electrification in this country. He said that the suppression of what was, after all, a very efficient machine, the steam locomotive, was still a long way off. While electric traction had practically captured the whole of the tramway traffic—of the 2464 miles of tramways 2286 are electrified and only 52 worked by steam—only 200 miles—single track—of railways in the United Kingdom were partly worked by electric traction, and only 204—single track—wholly worked by electricity. Abroad progress in this direction had been much greater, a fact he attributed partly to their hydro-electrical installations and partly to the fewer legal restrictions on high voltage lines.

ON Wednesday last, December 1st, trains commenced running on the South London electrified line of the Brighton Company. To distinguish this line from the many London tubes it is to be called "The South London Elevated Electric." In our issue of February 5th, 1909, we gave a general description of this railway, which is the second line to be operated on the single-phase system in this country. The equipment of the trains is a distinct advance on any hitherto seen in London, as will readily be appreciated from the illustrations given in our issue of February 12th. The average distance on the South London line between stations is, in round figures, 4600ft. The line has a great many curves and gradients, but, notwithstanding this, the average speed including stops is 22 miles an hour, and if the stops are not included it is just over 25 miles per hour. The electrification of this line has presented many unforeseen difficulties, and it has taken much longer to carry out than was originally anticipated. The tests on all the trains, we are informed, have proved very satisfactory, and the results are said to have been better than those guaranteed. The energy consumption per ton mile was some 15 per cent. better than that specified, and the same applies to the acceleration of the trains.

WE hear that it is probable that in the new year the fastest non-stop run in this country will be made by the London-Birmingham expresses on the London and North-Western Railway. At present the journey over the distance of 113½ miles is made in two hours, at an average speed of close on 57 miles per hour. It is now contemplated to cover the distance in 1 h. 47 min., or considerably over 60 miles an hour. The fastest scheduled running without stoppage is by the 1.8 p.m. North-Eastern express from Darlington to York—44 miles in 43 minutes, or 61.5 miles per hour. The next fastest is the Caledonian Railway's Perth to Forfar run, 32½ miles in 32 minutes, or 60.9 miles per hour. In the matter of fast runs the North-Western at present stands only tenth on the list, and is beaten by most of the other trunk lines. The race for the Midlands railway traffic has been very marked of late years between the London and North-Western and Great Western Railways. The journey by the former system is, of course, the shorter, and since the Birmingham non-stop expresses of two hours were put on swifter trains have been run by the Great Western too, so that competition is still very keen. The North-Western during the last few days have been running experimental trains between Euston and Birmingham and back, and the results obtained so far leave little doubt that there will be no difficulty in knocking off the 13 minutes.

THE Norwegian Railway from Christiania to Bergen extended until recently only as far as Gulsvik, which is 146 kiloms. from Christiania. The whole line was completed a few days ago, and the opening ceremony, consisting in a banquet attended by King Haakon, took place on the 26th of the month. The new railway is of great industrial significance, and is destined to be an important factor in international traffic, because it constitutes a continuation of the railway extending from the North Sea to the Far East through Sweden and Russia. The first preparations for the construction of this railway were made in the middle of the nineties, and consisted in the formation of roads for transporting the necessary construction materials and provisions into the mountains, which in some places rise to a height of 1500 metres above sea level. Workmens' dwellings were built and telephonic communication established. The material for the highest station on the line (Finse) had to be carried for a distance of 15 kiloms. up steep inclines by pack horses and bearers. The transport roads alone cost 800,000 kronen. The railway stations on the elevated section of the line are built of granite. In winter time large stores of provisions, clothing, &c., which cost large sums to transport, had to be deposited in these stations. About 2000 workmen were employed in summer in the mountain passes and in the tunnels; the work proceeded day and night, even on Sundays. The largest tunnel (Gravehals) is 5.3 kiloms. long. It was begun in 1895,

NOTES AND MEMORANDA.

THE Baccara (France) glass factory has just produced a new class of glass which, when heated to boiling point and then plunged into water at freezing point, will not break. The principal object was the making of safety lamp tubes superior to those made of the Jena product. The composition of the glass is, says the *Revista Minera*, roughly 70 per cent. bicarbonate of soda, 13 carbonate of manganese, 9 oxide of zinc, and 5 oxide of lead.

A FEW days ago, Professor Rutherford gave an address at the New Islington Hall, Manchester, on the subject of "Weighing an Atom." He traced the history of the atomic theory in science from the time of Greek culture to the present day, showing how it was really established definitely by John Dalton. The theory, he said, was the basis on which the whole foundation of chemistry rested. The chemist used the atom as a brick in the building of his house. Professor Rutherford then spoke of the movements, the weight, the size, and the constitution of an atom, showing how physicists had been able to determine these details.

THE operating costs at the Commonwealth Edison Company's Central Station, Chicago, are estimated as follows:—Fuel 20·8 per cent.; wages of generating staff, 6·1 per cent.; supplies and repairs for generating plant, 4·8 per cent.; battery and sub-station operation and maintenance, 12·1 per cent.; mains repairs and maintenance, 12·2 per cent.; reading and maintenance of meters, 6·8 per cent.; free lamp renewals, 16·6 per cent.; free maintenance of other current-consuming apparatus, 12·9 per cent.; free wiring and free repairs on consumers' premises, 7·6 per cent. Of the total, 31·7 per cent. is for generating costs, and 68·3 per cent. for distribution costs.

ACCORDING to the *Electrical Engineer* an interesting method for the transmission of photographs by telegraph and telephone, using the ordinary wires, has been invented by Professor Antonio Montagña. The inventor has discovered a system whereby he can decompose the pictures into elementary and graphic signs, which, when separated, can be designated by letters of the alphabet. The letters are transmitted in the usual way, and the operator who receives them is enabled to reconstruct the photograph by substituting the signs corresponding to the letters. The invention can be used by telegraph, telephone, and the wireless system, and photographs can be transmitted any distance.

IN a paper entitled "Applications of Electricity to Propulsion of Naval Vessels," which was read before the American Society of Naval Architects and Marine Engineers on November 18th, by Mr. W. L. R. Emmet, the author states that the efficiency of this electrical bond will be about 92 per cent. at all speeds, and this will remain constant through the life of the apparatus. He also doubts whether any other practicable form of speed reduction in such a ratio can be made equally efficient when all friction losses are considered, even if it should be proved that other methods are practicable at all for use in such large ships. The particular type of turbine proposed in this case affords the great advantage of good efficiencies throughout wide ranges of load and speed, as shown by test curves, which characteristics, in combination with the pole changing in motors, are of great value in such a case.

A LECTURE on "The Circulation of Water in the Earth" was recently given by Professor Boyd Dawkins at Manchester University. There were two definite systems of water circulation in Nature, Professor Dawkins said, one above ground, due to the heat of the sun, and one below ground, due to the heat of the earth. To this circulation of water below ground we might attribute some important effects, notably the equable flow of many rivers. A safe estimate of the amount of rainfall which found its way through the ground was about 10in. in 35. Thus there were a number of wells in and around Manchester, some of which yielded as much as 600,000 gallons a day. They drew their supply from the water which percolated through the superficial gravel and sand in surrounding districts. Professor Dawkins then outlined the water-bearing qualities of the various geological formations, and explained the difficulties presented by limestone and the advantages offered by chalk to those desirous of sinking a well.

IN a paper on "Works Organisation with a View to Profit Making," read by Mr. John Batey, before the Birmingham Association of Mechanical Engineers, the author stated that there seemed to be a widespread idea that organising in works for the production of special articles made it necessary to employ an expert in that particular line. This was true conditionally, because if an engineer who has had no experience of that class of work, were set to organise the manufacture of, say, cotton cloth, the ultimate result would not be good. But, given an engineer of general experience, with recognised ability and with brains, he was quite capable of organising a works to produce cheaply, and to make a profit with, some article he has never touched, given that such an article was within the province of pure engineering. It might be a locomotive or a bicycle, a motor car or a steamship, a machine tool or a gas engine, but it made no difference to an organiser, because he could organise up to a speciality in his line, though he has never touched the like before.

THE following particulars are given of the non-magnetic vessel Carnegie in a paper read before the American Society of Naval Architects and Marine Engineers:—The materials of construction are: Oak—keel, stern, stern-post, deadwoods, and frames; keelsons and beams, of Georgia pine; decks and spars, Oregon pine; rails and all deck joiner work, of teakwood. The use of iron in the construction of hull, spars, and joiner work was absolutely prohibited, and after exhaustive tests of different metals for non-magnetic qualities it was found that gun-metal composition was perfectly satisfactory, and that was used for practically all fastenings, except where pure copper was suitable. Windlass fittings, winches, anchors, and all fittings ordinarily of iron in this vessel are of gun-metal composition. It was found necessary to resort to the use of hemp hawsers for anchor cable, it being impossible to get anything in metal to suit this purpose. The engine is of the internal combustion, four-cylinder, four-cycle type, of approximately 150 horse-power, using producer gas. Reversing is done through a clutch. The entire engine, shafting, and propeller are of bronze, excepting the pistons, calm-rockers, and other minor parts, which it was deemed unsafe to make of bronze.

THE accuracy of gas-producer tests has been taken up in a recent bulletin of the U.S. Geological Survey, the data being based on tests made under the direction of Professor R. H. Fernald. The investigations were made as a result of the great inaccuracies which Professor Fernald states are apt to creep into tests of short duration, due principally to the practical impossibility of bringing the fuel bed to the same condition at the end of the test as at the beginning. The conclusions drawn by him as a result of the tests are summarised as follows:—"That throughout a test the fuel bed should be maintained in uniform condition, with regard to both the character of the fire and the thickness of bed; but that failing in this, special care should be exercised to see that the fuel bed is in the same condition and of the same thickness at the close of a complete test, or at the end of a test period, as at the beginning; that a test should never be started when the producer has been standing idle for some time with banked fires, as the fuel bed will not be in the average condition under which it will be required to work during the test; that if, as the appointed hour for closing the test approaches, the fuel bed is not in proper condition, the time of closing the test should be postponed until the bed naturally assumes the proper thickness and character. No forcing of conditions should be allowed simply to bring the test to an end at a previously determined hour."

MISCELLANEA.

DURING 1908 the number of new mining claims in Sweden amounted to 544 in all, of which 330 contain iron ore and 110 copper ore, and the remaining 104 other ores.

REPORTS from all sections of the United States furnish unmistakeable evidence, says the *American Architect*, that the building material interests' prospects for the coming year are brighter and fuller than at any time since 1906, if not in their entire history. The effects of the recent depression seem to have entirely passed.

A NEW bridge was recently opened at Lea in connection with the viaduct over the Kingsbury and Water Orton Railway. The late Lord Norton many years ago made the old bridge at his own expense, and gave it to the county. By joint contributions of the Midland Railway Company, county and district councils, and a gift of £350 by Lord Norton, there has been substituted for the old Red Birch bridge of steep gradients, a one-span iron girder bridge, with blue-brick abutments.

GOOD progress is being made with the new reservoirs for London, now being constructed at Island Barn, Walton-on-Thames, and at Chingford. Both were designed by Mr. W. B. Bryan, engineer-in-chief to the Metropolitan Water Board. The Island Barn reservoir will have a water area of 120 acres, and a capacity of a thousand million gallons. The Chingford reservoir has, too, progressed since March. It will cost £341,000, and is to be about three times the size of the Walton undertaking, and to have a water area of 416 acres, and a capacity of three thousand million gallons.

AN interesting series of tests has recently been made at the Engineering Laboratories of the Worcester Polytechnic Institute, Worcester, Mass., to determine the relative heat-transmitting properties of copper sheets just as they are received from the rolling mill and similar sheets electrically deposited. The apparatus used consisted of two double-disc Alden dynamometers with the rotating cast iron discs removed. The dynamometers as tested consisted of an outside cast iron casing and four copper sheets with the necessary spacing rings. The dynamometers were identical in every way, except in one the copper sheets were electrically deposited. The dynamometer containing the latter showed an increased heat transmission of more than 30 per cent. over the untreated.

As is now generally known, metallic filament lamps require only about one-half, if tantallum, or one-third, if tungsten, of the current of the carbon lamp of the same candle-power. On the other hand, the new lamps cost about four and six times as much as the carbon lamps, and usually work at 100 volts. Even so, the new lamps have a very wide field of usefulness, and this field has recently been greatly extended by the introduction of 200-volt lamps of low candle-power and reasonable cost, and by the marked improvements in the life and reliability of the metallic lamps, or, as they are often called, the wire lamps. With reasonable care, the effective life of a metallic lamp is from 60 to 100 per cent. greater than that of the carbon lamp, so that the relative cost of carbon and tungsten lamps should really be taken as about one to three, and is even less where the lamps are bought in ones or twos from small dealers. Where many people fail to obtain the full advantages from the new lamps is in installing too many lamps of large candle-power. It is possible to have too much illumination, and especially is it common to find powerful lamps so placed that they are trying to one's eyes.

SOME additional evidence pointing to a connection between sun spots and magnetic storms has been furnished by recent records in magnetic observatories. It is known that a spot of unusual size was on the sun's disc at the time of the great storm of September 25th. The sun's rotation brought the spot into approximately the same position on October 22nd, and a storm of quite noticeable character was perceptible from midnight on the 22nd till 8 p.m. on the 23rd ult. Also a storm on October 18th was preceded by one in September, again separated by the interval of one solar rotation. Professor Hale, of the Mount Wilson Observatory, has pointed out that in the course of experiments carried on in the physical laboratory he has observed that light, when subjected to a magnetic field, exhibits the same class of phenomena as he has perceived in sun spots. Professor Hale does not say definitely that solar magnetic conditions are the cause of terrestrial magnetic storms, for investigation has not gone far enough to establish such a theory; but he has furnished additional grounds for the belief that there is an interaction between these magnetic fields of the solar atmosphere and our terrestrial atmosphere, and that such action is related to terrestrial magnetic storms.

A PAPER by Mr. F. A. Macdonald was recently read before the members of the Edinburgh Association of Science and Arts on "Reinforced Concrete Construction." Among the advantages of reinforced concrete construction, the author stated, were rigidity and absence of vibration, durability, no subsequent outlay for maintenance, and resistance to fire. A general definition of what was meant by reinforced concrete construction might be stated as a combination of concrete and steel in a monolithic type of design, forming a homogeneous whole, in which the maximum of the inherent qualities of each of the two component materials was combined and fully developed. From the economic standpoint the saving of cost was not inconsiderable, and there was also a saving in deadweight, and consequent economy as regards pillars and foundations. The advantages of reinforced concrete construction had been recognised by the Government's great spending departments, and the lecturer stated that important works were shortly to be commenced in Scotland where reinforced concrete would be largely used. Recognising the importance of some standardisation of formulæ both as a safeguard and as a guide, the Royal Institute of British Architects had issued a set of regulations, which were very valuable, and gave data which could be intelligently worked on. Mr. Macdonald hoped that still further standardisation, both of formulæ and notation, for the calculation of reinforced concrete structures would be eventually drawn up and their observance recognised by all designers.

THE recent Admiralty order relegating certain of the old 27-knot destroyers to the list of subsidiary vessels, states a contemporary, marks the close of fifteen years' continuous service, these vessels having been completed for sea in the year 1893. The Ferret was the first of these destroyers to be delivered at Devonport, and for some time she was an object of much interest and importance, her commanding officer holding the rank of commander. The Admiralty order referred to will, it is understood, be given effect to gradually, the first vessels to be transferred at Devonport being the Starfish, Sturgeon, and Ferret. As, however, the remaining vessels of the type—over thirty in number—were completed for sea in 1894, and have also been continuously employed, they also may be considered as obsolescent, and will in the near future join the subsidiary list of vessels. The early removal of so many vessels from the active service flotillas would, under ordinary circumstances, be a matter for grave concern, but the Admiralty have made provision for their prompt replacement by new and much more efficient vessels of corresponding speed—27 knots—and only slightly inferior to the Tribal class in offensive and defensive qualities; and it is worthy of note that the launch of the Harpy, one of the pioneer vessels of the new class, took place on Saturday, November 27th, and is to be rapidly followed by that of the remaining vessels of this group. When the older vessels have been removed from the active flotillas it is not intended to dispense entirely with their services, as it is considered they can still do efficient work as harbour defence and mine clearing vessels.

THE SHIPYARD OF THE JOH. C. TECKLENBORG A.G. AT BREMERHAVEN

(For description see page 576)

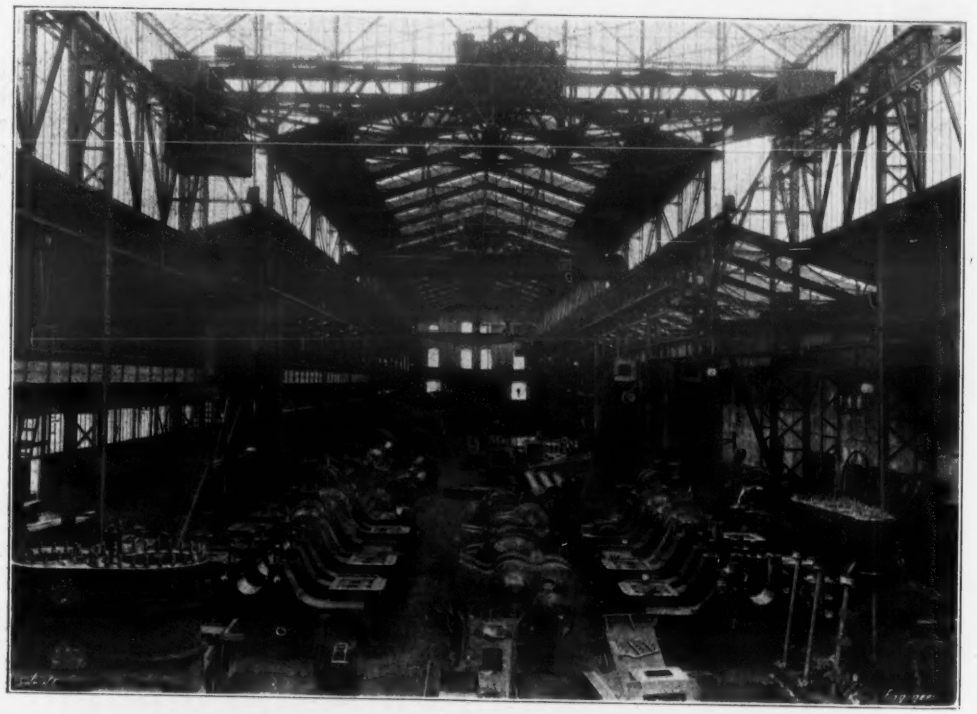


Fig. 11—ENGINE SHOP

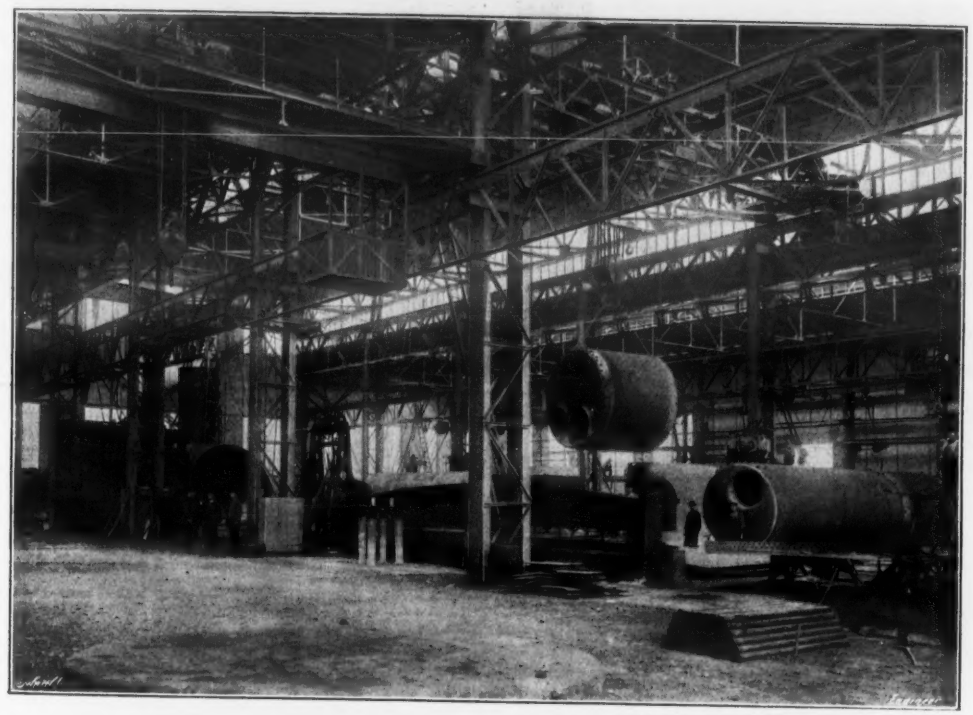


Fig. 12—THE BOILER SHOP

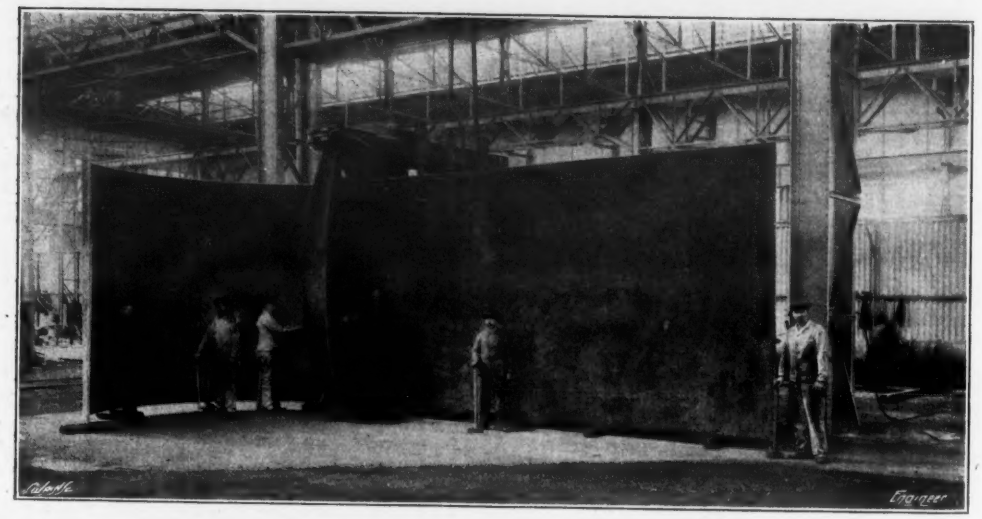


Fig. 13—PLATE BENDING MACHINE

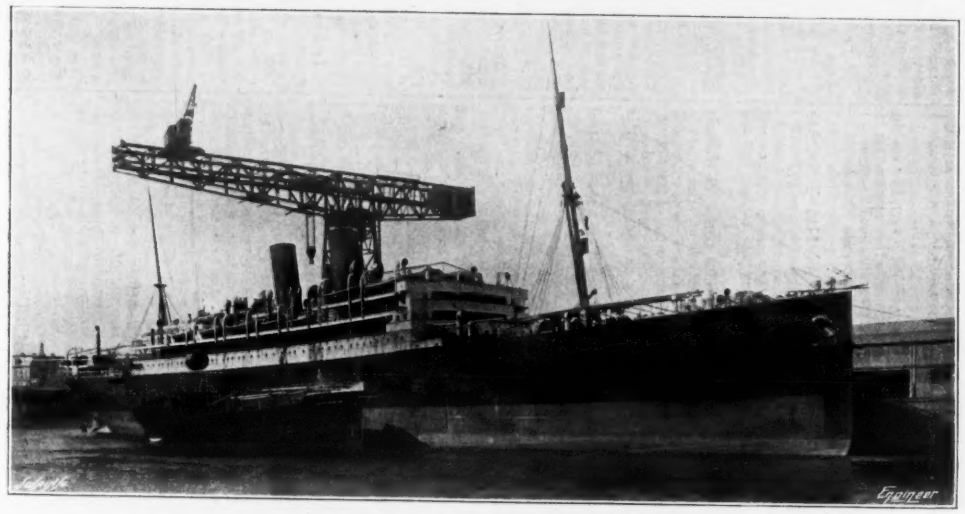


Fig. 14—150-TON REVOLVING TOWER CRANE

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Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other Letters to be addressed to the Editor of THE ENGINEER.

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PUBLISHER'S NOTICES.

*** *With this week's number is issued, as a Supplement, a Four-page Engraving of the Harbour Works at Fishguard. Every copy as issued by the Publisher includes a copy of this Supplement, and subscribers are requested to notify the fact should they not receive it.*

H.M.S. BELLEROPHON.

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CONTENTS.

THE ENGINEER, 3rd December, 1909.

	PAGE
NOVEMBER	569
FISHGUARD HARBOUR. (Illustrated.)	570
THE GERMAN NAVAL ARCHITECTS. No. II.	572
THE "ROCKET'S" DRIVER. (Illustrated.)	573
THE BRUSSELS EXHIBITION, 1910. (Illustrated.)	574
A 6000 HORSE-POWER DYNAMOMETER. (Illustrated.)	575
GERMAN SHIPYARDS. No. V. (Illustrated.)	576
NEW FRENCH DREADNOUGHTS	576
A LARGE COLUMNLESS GASHOLDER. (Illustrated.)	577
THE LAUNCH OF THE SECOND-CLASS CRUISER NEWCASTLE	578
OBITUARY	578
DOCKYARD NOTES	578
A NEW ALUMINIUM SOLDER	578
RAILWAY MATTERS	579
NOTES AND MEMORANDA	579
MISCELLANEA	579
LEADING ARTICLES—Novel Types of Warships	581
Inland Waterways and Railways—The Purchase of Rolling Stock	582
NOTES ON THE DESIGN OF SHAFTS, WITH SPECIAL REFERENCE TO HIGH-SPEED ELECTRIC GENERATORS. No. IV.	583
THE NEW CAPITAL OF AUSTRALIA	584
THE NEW GERMAN STEAM BOILER LAW	584
THE COMPULSORY WORKING OF PATENTS	584
THE WHITE STAR LINERS OLYMPIC AND TITANIC. (Illustrated.)	585
TROUBLES IN AUSTRIA	585
WINDING ENGINE DESIGN. (Illustrated.)	586
AN INTERNAL COMBUSTION PUMP AND OTHER APPLICATIONS OF A NEW PRINCIPLE. (Illustrated.)	586
LETTERS TO THE EDITOR	587
THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS	589
NOTES FROM LANCASHIRE	589
THE SHEFFIELD DISTRICT	589
NORTH OF ENGLAND	589
NOTES FROM SCOTLAND	590
WALES AND ADJOINING COUNTIES	590
AMERICAN NOTES	590
NOTES FROM GERMANY, FRANCE, BELGIUM, &c.	591
BRITISH PATENT SPECIFICATIONS. (Illustrated.)	591
SELECTED AMERICAN SPECIFICATIONS. (Illustrated.)	592
FOUR-PAGE SUPPLEMENT—HARBOUR WORKS AT FISHGUARD.	

TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

VAGRANT.—Your proposal that part of the weight of a locomotive should be transferred from carrying to driving wheels is old. Patents have been taken out for arrangements of the kind. See abstracts "Aids to Locomotion" at the Patent-office Library.

R. W. (Upton Park).—If you get into a marine shop, and from there get to sea, you might be permitted, after having served at least one year at sea, to sit for examination for a second's certificate. As a rule, however, training in steam engine works is held to be necessary. Get a copy of the Board of Trade "Regulations for the Examination of Engineers in the Mercantile Marine," price 6d.

MEETINGS NEXT WEEK.

INSTITUTE OF MARINE ENGINEERS.—Monday, December 6th, at 8 p.m., at 58, Romford-road, Stratford, E. Paper, "The Engine-room Telegraph," by Mr. J. M. Newall.

SOCIETY OF ENGINEERS.—Monday, December 6th, at 7.30 p.m., in Room 18, Caxton Hall, Westminster. Ordinary meeting. Paper, "The Mechanics of Dust," by C. H. W. Biggs.

GEOLOGISTS' ASSOCIATION, LONDON.—This evening, at 8 p.m., at University College, Gower-street, W.C. Lecture, "The Volcanic and Alpine Regions of New Zealand," by Albert E. Kitson, F.G.S.

THE ASSOCIATION OF ENGINEERS-IN-CHARGE.—Wednesday, December 8th, at St. Bride's Institute, Bride-lane, Fleet-street, E.C. Paper. "Recent Developments in Impulse Steam Turbines," by Mr. George B. Williamson. (Illustrated by lantern slides.)

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 9th, at 8 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Ordinary general meeting. Paper, "Notes on Methods and Practice in the German Electrical Industry," by L. J. Lepine and A. R. Stelling.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 7th, at 8 p.m., at Great George-street, Westminster, S.W. Ordinary meeting. Paper, "Marine Propulsion by Electric Motors," by Henry Alexander Mavor, M. Inst. C.E. Wednesday, December 8th. Students' visit to Messrs. Barclay, Perkins and Company's Brewery, Park-street, Southwark, S.E.

ROYAL SOCIETY OF ARTS.—Monday, December 6th, at 8 p.m., at John-street, Adelphi, London, W.C. Cantor Lecture: "Aeronautics," by Charles Cyril Turner. Wednesday, December 8th, at 8 p.m. Ordinary meeting. "The Destruction of Plumage Birds," by James Buckland. Thursday, December 9th, at 4.30 p.m. Indian Section. "The Punjab," by Sir James Wilson, K.C.S.I.

THE ENGINEER.

DECEMBER 3, 1909.

Novel Types of Warships?

A CHARACTERISTIC of the sea serpent is that one never knows where it will make its appearance next. Though this is not the "silly" season, we are led to the above reflection by a perusal of the recently published "Navy League Annual," where the gas-engined battleship is again put forward as a possibility to be reckoned with in the immediate future. It is not, however, our present purpose to waste words on this subject. The futility of building up a design on conjectures about a type of machine which is yet in its infancy as regards application to marine propulsion was made fully apparent at the last spring meeting of the Naval Architects. The erroneous deductions frequently made as to the weight and space required for gas engines have been exposed in our columns, and the general situation as to the present impracticability of gas engines in large sizes for warship propulsion was accurately expressed in the presidential address of Admiral Oram to the Junior Institute of Engineers. Nevertheless, we suppose the gas-engined battleship will continue, like the sea serpent, to make occasional visits. We would merely remark that as one of the aims of the Navy League is educational, it should exercise some sort of discrimination as to the matter included in its "Annual," or else label it, as Artemus Ward used to do, with the words "N.B.—this is a goak." The truth is that speculation on ship designs, and warship designs in particular, is fascinating but, on the whole, unprofitable work. The practicability of associating a number of qualities together in a design can only be determined by the trained naval architect after a great many calculations have been made. The design-monger as a rule thinks of the military qualities only—speed, armour, and armament, whereas the naval architect has to determine how much of each of these qualities can be combined in a vessel which shall at the same time have sufficient strength, stiffness, seaworthiness, and stability. Take, for example, a suggestion in another article of the Navy League Annual that some of our obsolete warships could be converted into floating batteries. The writer suggests that such vessels as the old Devastation could have had modern 12in. guns to replace the old 10in., six or eight 4.7in. quick-firers mounted on a superstructure amidships, and the old iron armour replaced by modern. "Thus by *intelligent* modification—the italics are ours—we should have a vessel substantially suited for bombarding purposes." The writer goes on to require minute sub-division of the hull, and torpedo net defence. It all sounds so very simple, yet a little consideration will show that the proposals involve the redistribution of a very large proportion of the displacement, mostly in the direction of adding top weight, and the possibility of doing it without destroying stability altogether is very much open to question. When to this consideration is added the very large expense of removing the old armour and replacing it by new, and of fitting the additional water-tight bulkheads to give the minute sub-division of the hull, the absurdity of the scheme is manifest. If floating batteries are necessary, it would be much cheaper to build new vessels. The question of reconstruction has often been before the various Admiralties confronted with a number of obsolete vessels. The policy of our own Admiralty has almost invariably been against it, as the gain can never be shown to be commensurate with the cost. There is always, too, the further difficulty to which we have previously referred. The general tendency of progress on warships is towards lighter machinery and heavier armour and armament, and to reconstruct a ship to bring her up to date means taking weight from below and adding it on top, with a consequent reduction of stability. The writer of the article to which we have referred goes on to suggest the building of an improved Polyphemus, the line of argument being that speed in destroyers cannot go on increasing indefinitely, that the secondary armament of battleships must be increased in size, and, therefore, the torpedo boat destroyer must be armoured to provide protection against the increased size of projectiles. The writer mentions a proposal, which has been made in an Austrian publication, for a torpedo battleship carrying thirty submerged torpedo tubes and twenty 4.7 guns, and then suggests that the improved Polyphemus could be made a good deal smaller than this, having a 6in. armoured cigar-shaped hull—there is much virtue apparently in the cigar—carrying six or eight tubes, a few 4.7 guns, and able to steam at 28 to 30 knots. We are not much concerned with the assumptions made, nor of the subsequent flight of the imagination by which the writer arrives at the type of vessel which is to replace existing torpedo craft; the reasons for embarking on an experiment of this sort are altogether inconclusive. The lessons to be gained by the construction of these freak vessels are at the best negative, in that they are generally failures, and only serve to indicate what should be avoided rather than to give any positive lead in new construction. The Polyphemus herself was a case in point. As originally conceived by Admiral Sartorius, she was much of the shape of the present submarines, but modifications had to be made to prevent undue pitching, and to give a reasonable amount of stability. These changes consisted in the addition of a superstructure forward and aft, and some 250 tons of ballast in the form of huge cast iron blocks housed in a wide hollow keel. Some of these could be dropped in the event of the vessel shipping water, a precaution considered necessary by the low reserve of buoyancy. Designed primarily for ramming, she had also five submerged tubes, four on the broadside and one at the bow. As an effective fighting unit she was never of any value, and the only excuse that could be urged for keeping her so long in commission was that at the time she had more torpedo tubes than any other vessel in the service, and served as a training ship, though she was never officially recognised as such. We need not recapitulate the early troubles with her locomotive boilers (subsequently replaced by cylindrical) nor the historic "jumping the boom" in Bantry Bay after she was finally completed for service. Her full speed could not be realised without heavy forcing of the boilers, and at natural draught she was barely equal to 14 knots. She was a most uncomfortable ship to live in and a bad sea boat, while her range of stability was sufficiently small to give rise to a certain amount of anxiety in bad weather. Added to this, her coal capacity was so low that the passage from Portsmouth to Gibraltar at economical speed could not be undertaken without calling at an intermediate port for coal.

We have learnt by experience that the safest way in warship progress is development by successive stages. The 1200-ton ocean-going destroyer of the present day is the direct lineal descendant of the earliest torpedo boats of only one-fiftieth the displacement of thirty years ago. So far as one can make any conjecture at all, it appears probable

that if a torpedo vessel on the lines of the Polyphemus is to come again into being (*i.e.*, with submerged tubes in contra distinction to the above water tubes of the present destroyers), it will be as a development of the present submarine. In an article on the evolution of submarine vessels, far removed in its tenour from the crude speculation of the two other articles in the "Annual" from which we have quoted, M. Laubeuf considers it will be wise to stop at 600 tons displacement, which will allow a surface speed of 16 knots. The increasing difficulty in providing the necessary power as the size of the submarine is increased will no doubt make progress slow, and unless rapid developments are made in the internal combustion engines used for propulsion, it will be several years before the 600-ton limit laid down by M. Laubeuf, which has already been attained by our own D 1, is exceeded. M. Laubeuf, for reasons of seaworthiness among others, prefers the submersible with a larger reserve of buoyancy to the submarine proper, and if the functions of this type of vessel are to be extended, it may well be that as they grow in dimensions the reserve of buoyancy will be increased, and eventually the ability to dive done away with altogether. Whether such a vessel, which would sacrifice invisibility for the sake of speed and sea-keeping qualities, would be sufficiently useful to justify its existence, depends to a large extent on the development of other classes of ships, but to pursue the matter further would be to enter into those realms of speculation the exploration of which beyond very moderate limits we have already deprecated.

Inland Waterways and Railways.

It is expected that the final Report of the Royal Commission on Canals and Waterways will be presented within the next few weeks, and in all probability the document will be in the hands of the public before the close of the year. There is little likelihood that the Report will be unanimous—in fact, more than one Minority Report may be expected. In view of the interest which is sure to be aroused by the publication of the Report, it is worth while recalling some of the conclusions which have been arrived at by a Commission appointed by Mr. Roosevelt in 1907 to make a similar inquiry into the condition of the inland waterways of the United States. The preliminary Report of the Commission has been published, and deals exhaustively with the general question of inland navigation in the States, detailed recommendations as to works to be undertaken in connection with the waterways being apparently reserved for a later Report. Incidentally, the Commissioners discuss the condition of inland navigations in Europe, and make some shrewd criticisms on the causes which have led up to the existing state of affairs, not only in the United Kingdom, but in other countries, and on the future possibilities of canals and railway transport.

Mr. Roosevelt, in his message covering the Report, stated that the appointment of the Commission was due to "the general and admitted inability of the railroads to handle promptly the traffic of the country, and especially the crops of the previous fall," and this statement is borne out by the findings of the Commissioners. On the other hand, however, the existing inland navigations are not employed nearly to their full, and the Commissioners in a paragraph, which is particularly applicable to the conditions obtaining in our own country, recommend that "any plans for improving the inland waterways shall take account of the present and prospective relation of rail lines to such waterways, and shall ascertain, so far as may be, whether such waterways when improved will be effectively used in the face of railway competition." When one remembers the immense extent of natural inland waterways in the United States and the many efficient canals, the serious decline in the water-borne traffic is a factor which cannot be neglected in estimating the future prospects of inland navigation not only in America but in our own country. The Commissions seek to apply the lessons which they are able to draw from the history and present conditions of European waterways to their own needs, and have come to the conclusion that the revival of interest in waterways, taking place at about the same period in different countries, is due to dissatisfaction with railroad conditions, and to a developing opinion that best results may be secured by the exploitation of both transportation systems—rail and water. As to this belief they say:—"In no country has it been possible to secure satisfactory development of both systems until one was protected against the other. As a rule, it has been necessary to invoke the power of the State to save the traffic of waterways from destruction by railway competition." Yet they believe that this fact by no means demonstrates the economic inutility of waterways, and experience has convinced those countries which have fostered inland navigation that the best and most economic transportation is to be secured only by maintaining both systems at high efficiency. Great Britain is set down as the one exception among European industrial countries in which this fostering policy has not been practised; the reasons for this state of affairs are admirably and succinctly summarised in a paragraph which we quote in full:—"It was doubtless only natural that in Great Britain and the United States the waterways revival should have been postponed longer than in continental countries. It is fashionable to attribute the delay in these two countries to the influence of the railroads, and no doubt this was a factor of importance. But other considerations must be assigned due weight. In England the most important consideration was the easy accessibility of ocean transportation; and, secondly, was the fact that for various physical reasons the construction of canals is more difficult and expensive in England than in most continental countries. England has no such great rivers as the Danube, the Rhine, the Elbe, the Oder, the Seine, and other great water highways of the Continent. The topography of Great Britain makes canal construction more difficult than on the Continent. The country is more uneven, and more locks would be required, involving greater expense. The question of water supplies for the higher levels is so serious as, in the opinion of some authorities, to bar Great Britain from ever securing economically a system of waterways approaching the efficiency of those in France, Belgium, the Netherlands, Germany, and even Austria-Hungary." This expresses very concisely the differences that exist between the United Kingdom and the Continent of Europe, and should be borne in mind by those who use the argument that because Germany, France, or Belgium have found canals profitable we also should do the same. Advocates of waterway development have to face the fact that in different countries it has been found necessary to adopt vigorous measures to prevent the railways from destroying the business of the waterways by the simple process of hauling freight more cheaply than it could be moved by water, and, we might add, more expeditiously. This is a fact which must be explained away in any effective argument in favour of water transportation as against railways. Not only in the United Kingdom, but in Germany, in France, and in Belgium, three countries whose waterway systems have reached the highest perfection, the railways have proved their ability to take the tonnage away from water routes and to keep it away from them. Railways have done this, too, in the face of the fact that they are required to earn not only working expenses, but heavy charges on capital, while the canals are operated in the main free of charge. Practically the only expenses attached to water transportation on continental navigations is that for mere operation of boats and barges. The water highway has been provided at Government expense. Commerce moving on it has not been expected to remunerate the State, or even to pay interest on capital. With the railways thus handicapped, if the waterways cannot take care of themselves the burden is upon waterway advocates to prove the waterways' economic right to survive. On these lines the Commissioners state the case against the advocates of waterway extension and their presentment cannot be too carefully studied. They then proceed to state the case for water transportation as applied to the needs of their own country, and they are certainly able to show that the development of a policy of fostering their waterways in certain directions may be justifiable and desirable if only the principle of restriction of railway competition is admitted.

It is needless to point out that the physical conditions of the waterways, natural and artificial, in the United States are very different from those which surround our own, and while the Commissioners draw their conclusions from the facts of British and continental navigation, and use them in formulating a policy of development for their own needs, it is evident that they do not intend their findings to be applicable to the question as presented in this country, and naturally it is outside their province to attempt the task of supplying an opinion on the future of our own waterways. But coming from a body of expert investigators, whose impartiality as regards the inland navigations of Europe cannot be questioned, the statements we have summarised are of no little value, and it will be of interest to know, when the Report of the Royal Commission is issued, how far they are confirmed by the investigations of that body.

The Purchase of Rolling Stock.

A circumstance which recalls the manner in which orders are occasionally placed with British firms for the delivery of locomotives and rolling stock in general for the Indian railways has just arisen in France, where the question of railway requirements in French colonies and protectorates comes into consideration. The proposed method of dealing with the problem possesses a certain amount of interest in the United Kingdom at the present time. The system, or rather the lack of system, under which contracts are distributed in France has long been a source of complaint on the part of French locomotive and wagon builders, as they have for many years past either been inundated with orders or have had comparatively little work to complete for the home and colonial railways, whether State owned or the property of companies enjoying Government guarantees; and when the builders find that a certain amount of business is being, and is likely to be, again diverted to other countries, so as to effect rapid delivery, they are inclined to conclude that the existence of such a practice is scarcely in the interest of national industries. In the circumstances the leading French firms recently approached the Government with the object of bringing pressure to bear to prevent orders for locomotive and rolling stock being placed in other countries, or at all events to secure greater regularity in the allocation of contracts to native builders. It is noteworthy that this application has been acceded to, in so far that the Minister of Public Works has appointed a Government Commission to inquire into the technical, economic and administrative conditions under which orders are assigned to makers, and the construction of locomotives and rolling stock in France, and to submit recommendations on the subject. The Commission, which has as President the General Inspector of French Means of Communication, is also composed of representatives of the principal railways, various Government departments, locomotive builders, and the iron and steel trades; and the report to be prepared on the matter is to be ready in the short period of four months. The chief object of the commission is to investigate the problem as to the adoption of a more regular course in the distribution of French railway orders, and the commission will in pursuance of it pay visits of inquiry to Germany, Belgium, and England.

The appointment of this Government Commission of Inquiry has been received with satisfaction in France, especially as some railway orders have recently been sent over the frontiers, and as extensive contracts for 1910 are believed to be in contemplation. By a curious coincidence, an unofficial investigation of the identical question was made early in 1908 both with regard to Belgium and France, and the documentary evidence then collected showed an extraordinary variation in the distribution of orders in both countries in a period extending over the twenty-five years ended with 1905, whilst the expansion which took place in the following year was truly phenomenal. The case of Belgium may be left out of consideration, except to notice that the State Railway authorities pursue the same erratic policy in the allocation of orders as the French railway companies, and probably, also, the State Railways, although the Belgian work is apparently all entrusted to native firms for execution. On the other hand, various French orders have been given to German works and Belgian builders, and a Teutonic newspaper actually stated a few weeks ago that in a recent year German works supplied locomotives to France alone of the value of £5,000,000. The assertion is, however, a vast exaggeration, seeing that the total value of the rolling stock, apparently including locomotives, ordered in France in 1906, which is obviously the year referred to, and which was the year of maximum expenditure incurred by the French railways in this direction, amounted only to the sum—enormous enough—of £5,486,000, and of it contracts representing only £968,000 were allocated to other countries. No doubt Germany received the greater portion of the work, and Belgium would probably rank second, whilst British locomotive builders participated to the extent of no more than £27,000; but it is uncertain from the Board of Trade returns whether Great Britain had any share in the provision of the coaches and wagons which were included in the total value of the contracts in that year.

The productive capacity of the French locomotive builders is estimated at 450 engines per annum, whereas the minimum number of engines ordered by the

French railways in a single year during the quarter of a century ended with 1905 was 38, the maximum was 741, and the next highest was 315. With such wide variations in the number of locomotives, and with similar divergences in the case of rolling stock, it is scarcely surprising to find that the lack of foresight in a period of rising prosperity causes a diversion to other countries of a portion of the work which could have been carried out by native builders if it had been equally distributed over other years when trade was less satisfactory, raw materials cheaper, finished manufactures obtainable at lower prices, and delivery more readily and speedily effected. A similar observation was applicable to India a few years ago in so far as British builders were concerned, and also to South Africa and probably Egypt, but it was of a less pronounced character than in France from a commercial point of view. Even at the present moment there can be no doubt that railway material might be bought in Sheffield at a considerable advantage. In the case of India alone a sum of nearly £250,000 was expended both by the Government and the private railways in 1903-4 on the purchase of locomotives from Germany, although the imports from that country in this respect have ceased since that time, but the acquisition of foreign rolling stock, particularly from Belgium, has continued for both classes of railways, excepting for the State lines in 1907-8. Notwithstanding the large loss to the State on the working of the Indian railway system in 1908, the trade of the country is improving, and is now regarded as reviving, and it may be that the needs of the railways in the matter of additional locomotives and rolling stock will soon begin to manifest themselves. As soon as these indications become visible, it should be open both to the State and the private railways to make early preparations for meeting the expected requirements of traffic. If the State is unable to provide the additional £2,000,000 per annum recommended by the Committee on Indian Railways for works and equipment, increased facilities should be afforded the companies for raising any additional capital required for the purpose, and if the negotiations which were recently referred to in the House of Commons are successful, there is hope of an improvement in the future; but this will scarcely affect the question that a more equal distribution of orders over various years is a desirable object which should be sought as far as possible.

NOTES ON THE DESIGN OF SHAFTS, WITH SPECIAL REFERENCE TO HIGH-SPEED ELECTRIC GENERATORS.

By H. H. JEFFCOTT.

No. IV.*

22. In addition to avoiding the two mechanical causes of lateral instability treated in my last article, it is, of course, of the greatest importance that a sufficient factor of safety should obtain in any given case. We will examine the factor of safety for a load consisting of flexure, torsion, and rotational stresses.

Let the shaft be under a force X perpendicular to its length at a point distant z_1 from one end (the origin), be under a torsion couple H, and be rotating with a velocity ω. If e, f, g, a, b, c be the six strain components at any point (x, y, z) in the shaft, it may be shown that

$$e = -\mu\sigma(l - z_1)zx + \lambda\left\{(3 - 2\sigma)a^2_1 - 3x^2 - y^2\right\}.$$

$$f = -\mu\sigma(l - z_1)zx + \lambda\left\{(3 - 2\sigma)a^2_1 - x^2 - 3y^2\right\}.$$

$$g = \mu(l - z_1)zx.$$

$$a = -\tfrac{1}{2}\mu(l - z_1)xy(1 + 2\sigma) + \tau x.$$

$$b = \tfrac{1}{2}\mu(l - z_1)\left\{\left(\frac{3}{2} + \sigma\right)(a^2_1 - x^2) + (\sigma - \tfrac{1}{2})y^2\right\} - \tau y.$$

$$c = -4\lambda xy.$$

Where $\lambda = \dfrac{\omega^2\rho(1 + \sigma)(1 - 2\sigma)}{8E(1 - \sigma)}$, $\mu = \dfrac{X}{EIl}$, $\tau = \dfrac{H(1+\sigma)}{EI}$, σ is Poisson's ratio, and ρ is the density of the material; a_1 is radius of section of shaft, $I = \frac{1}{4}\pi a^4_1$.

These are the strains from o to z_1. From z_1 to l the strains are obtained by writing $l - z$ for z, and $l - z_1$ for z_1. If the shaft is under torsion throughout the length o to z_1 only, we put $\tau = o$ for the portion z_1 to l.

23. If the shaft be hollow, of external and internal radii a_1 and a_2, then the strain terms in λ become

$$e = \lambda\left\{(3 - 2\sigma)(a^2_1 + a^2_2) + \frac{3 - 2\sigma}{1 - 2\sigma}\cdot\frac{a^2_1 a^2_2}{(x^2 + y^2)^2}(y^2 - x^2) - 3x^2 - y^2\right\}.$$

$$f = \lambda\left\{(3 - 2\sigma)(a^2_1 + a^2_2) + \frac{3 - 2\sigma}{1 - 2\sigma}\cdot\frac{a^2_1 a^2_2}{(x^2 + y^2)^2}(x^2 - y^2) - x^2 - 3y^2\right\}.$$

$$g = a = b = o.$$

$$c = -4\lambda xy\left\{1 + \frac{3 - 2\sigma}{1 - 2\sigma}\cdot\frac{a^2_1 a^2_2}{(x^2 + y^2)^2}\right\}.$$

* No. III. appeared November 12th.

24. It is to be noted that if the load X is unidirectional (as gravity) the strains set up in the shaft thereby will vary in direction as it rotates. Thus, the load is of the nature of a rapidly (though gradually) reversed load, and, according to Wöhler's results, the ordinary breaking stress is seriously reduced: a factor of safety of about three will be required.

It is important further that the period of reversal (*i.e.*, the speed of the shaft) should not be nearly equal to the free period of vibration of the particles of the shaft (in the gravitational displacement type), else the alternating displacements may become very great and the strains be cumulative. This period is approximately the period of longitudinal vibration of the loaded shaft. Above this speed the period of reversal of the load is more rapid than that in which the ordinary (gravitational) displacements can occur, and the amplitude of the displacements falls off in consequence. In other words, the shaft tends to straighten out, for, with the neutral axis more nearly straight, the gravitational displacements at any point are less. Further, if a dynamo shaft thus becomes less deflected by gravity, the armature is raised higher in the field than before, and the upper poles exert a greater force than the lower; so that for this reason in addition the shaft will still more tend to straighten.

The higher the speed the greater the tendency for the neutral axis to be straight (instead of curved in the single gravitational loop), while at or near the longitudinal vibration speed there is a possibility of cumulative strains. It should be noted, however, that this speed is considerably higher than that at which dynamos are usually run.

Now, if the factor of safety be taken as dependent on the maximum strain, we may notice that above the longitudinal vibration speed the strains due to the gravitational or flexural load become less. The higher the speed, however, the greater are the rotational strains, so when the rotational strains become great the flexural strains may fall off. If, indeed, the speed be indefinitely great the strains due to the flexural load become evanescent on the ordinary theory of beams. The material along a straight line parallel to the neutral axis and distant r from it would, if the shaft were bent, experience a forced alternate extension and compression of period equal to the period of rotation of the shaft. When the speed is infinite this material would require to have an infinite velocity longitudinally in alternately opposite directions, and this infinite velocity would have to be produced by a finite force (gravity) acting for an indefinitely short time. Hence, the shaft axis is straight at such a speed.

Mathematically, the reasoning is as follows:—Consider a particle of a fibre which is parallel to the neutral axis. Its equation of motion is of the type $a\dfrac{d^2z}{dt^2} + b\dfrac{dz}{dt} + cz = f\sin pt$, where a is its mass, b the coefficient of damping, c the elastic force of restitution, and $f\sin pt$ is the disturbing force at any instant t, so that p is the frequency (multiplied by 2π) of the force. The solution of this equation is

$$z = \frac{f}{\sqrt{(ap^2 - c)^2 + b^2p^2}}\sin(pt + \beta) + Ae^{-\frac{bt}{2a}}\sin(p't + \alpha),$$

where A and α are arbitrary constants, $\tan\beta = \dfrac{bp}{ap^2 - c}$ and the frequency (multiplied by 2π) of free vibration p' is $\dfrac{\sqrt{4ac - b^2}}{2a}$.

If t be sufficiently great the exponential term is negligible, so that the final amplitude of the forced vibration is given by $\dfrac{f}{\sqrt{(ap^2 - c)^2 + b^2p^2}}$. This is maximum when $p = \dfrac{\sqrt{4ac - 2b^2}}{2a}$, and we notice that this value of p approximates to p' when the damping b is small. Thus the amplitude increases from $p = o$ to $p = \dfrac{\sqrt{4ac - 2b^2}}{2a}$, after which it falls off to zero when p is infinite; p is, of course, proportional to the speed.

If we neglect damping we may determine the free period of longitudinal vibration of the particles of the shaft, at which a possibility of cumulative strain occurs. The usual Bernoulli-Eulerian assumptions will be made.

Consider a particle of a thin fibre which is parallel to and at a distance r from the neutral axis in its gravitationally deflected position. The equation of motion for forces parallel to the length of the shaft is $\rho\dfrac{d^2w}{dt^2} = E\dfrac{d^2w}{dz^2}$, where ρ is the density of the material of the shaft, and w is the component of displacement of the particle parallel to the length of the shaft.

Now $w = r\theta\sin\omega t$, if θ is the inclination of the neutral axis at the point considered to its unstrained direction, and if the neutral axis be supposed to remain stationary, θ is independent of t. Then $-\rho\theta\omega^2 = E\dfrac{d^2\theta}{dz^2}$. If we assume $\theta = C\sin kz$ we find $\omega^2 = \dfrac{E}{\rho}k^2$. Now for a uniform massive shaft of length $2l$, supported at its extremities, $\theta = \dfrac{g\rho A z}{6EI}(3l^2 - z^2)$, where A is the area of cross-section. In order that ω may represent approximately the free period of the deflected shaft, we determine k, so that the two values of θ are the same at a number of points along the shaft.

Let us choose the points $-l, -\frac{1}{2}l, o, \frac{1}{2}l, l$, the origin being the middle point of the shaft.

$z = o$ gives $\theta = o$ in both equations.

$z = \pm\frac{1}{2}l$ gives $C\sin\frac{1}{2}kl = \dfrac{11g\rho A l^3}{48EI}$.

$z = \pm l$ gives $C\sin kl = \dfrac{g\rho A l^3}{3EI}$.

Hence $\cos\frac{1}{2}kl = \dfrac{8}{11}$, and $\therefore \frac{1}{2}kl = 2n\pi \pm 0.75645$.

$$\therefore k = \frac{\pi}{2l}\times\left\{8n \pm 0.963\right\}.$$

Hence $\omega = \dfrac{\pi}{2l}\sqrt{\dfrac{E}{\rho}}\times\left\{8n + 0{\cdot}963\right\}$.

Accordingly the particles of the bar have a free period of longitudinal vibration ω given by this equation, when the curvature of the bar approximates to the gravitationally deflected form. It will be noticed that the fundamental period of this approximate result does not differ much from $\dfrac{\pi}{2l}\sqrt{\dfrac{E}{\rho}}$, which is the free period of longitudinal vibration of the half bar when straight.

It may be noticed here that Dr. Stodola, in his treatise on the "Steam Turbine," gives a mathematical determination of the period of longitudinal vibration of the particles of a deflected shaft. Unfortunately, there is a serious error in the application of D'Alembert's equation of moments at the outset of the work. The effective, or accelerative, force of the particle parallel to the length of the shaft is duly considered, but the effective force at right-angles to the length, and in the plane of bending, is entirely omitted from the equation of moments. If it were included, the moment of the effective forces about a line perpendicular to the plane of bending would be found to vanish, and so the method of solution fail.

25. In estimating the strength of the shaft, we may follow the greatest strain theory, in which the greatest strain at any point is limited. In this case the expressions for the strains e, f, g, a, b, c at each point are to be transformed to the principal planes of strain, and thus the principal strains e_1, f_1, g_1 determined.

If Φ be the factor of safety, and T_o the longitudinal breaking stress, the maximum greatest value of e_1, f_1, g_1 at any point $= \dfrac{T_o}{E\Phi}$.

If we follow the greatest stress theory, we have to limit the maximum greatest of the principal stresses P_1, Q_1, R_1 (which are obtainable from e_1, f_1, g_1 and certain elastic constants). The maximum greatest of P_1, Q_1, R_1 at any point $= \dfrac{T_o}{\Phi}$.

The maximum stress difference theory of strength requires that the greatest difference in the principal stresses (P_1, Q_1, R_1) at any point shall not exceed a certain value for the material, the factor of safety being again the ratio of the limiting value to the maximum value present.

26. In general it is difficult to determine the values of e_1, f_1, g_1, and the maximum greatest principal strain. It is easier to examine separately the strains due to flexure, torsion and rotation.

1. *Flexure.*—Strains are

$e = f = -\mu\sigma zx(l - z_1)$.

$g = \mu zx(l - z_1)$.

$a = -\frac{1}{2}\mu xy(1 + 2\sigma)(l - z_1)$.

$b = \frac{1}{2}\mu(l - z_1)\left\{\left(\frac{3}{2} + \sigma\right)(a^2_1 - x^2) + (\sigma - \tfrac{1}{2})y^2\right\}$.

$c = o$.

We may note that a, b, c are small compared with e, f, g, since x, y are generally small compared with z. Omitting a, b, c, we can regard e, f, g as principal strains, which are then

$e_1 = f_1 = -\mu\sigma zx(l - z_1)$; $g_1 = \mu zx(l - z_1)$.

The greatest of these is $\mu zx(l - z_1)$, which is maximum when $z = z_1$, and $x = a_1$. Thus, the maximum greatest principal strain due to flexure is $g_1 = \mu z_1 a_1(l - z_1)$.

2. *Torsion.*—Here the strains are

$e = f = g = c = o$; $a = \tau x$, $b = -\tau y$.

Hence $e_1 = -f_1 = \frac{1}{2}\tau\sqrt{x^2 + y^2}$; $g_1 = o$.

The maximum greatest principal strain due to torsion is $e_1 = \frac{1}{2}\tau a_1$, and it occurs at any point on the surface of the shaft.

3. *Rotation.*—The strains are

$$e = \lambda\left\{(3 - 2\sigma)a^2_1 - 3x^2 - y^2\right\}.$$

$$f = \lambda\left\{(3 - 2\sigma)a^2_1 - x^2 - 3y^2\right\}.$$

$$g = a = b = o.$$

$$c = -4\lambda xy.$$

Hence we find

$$e_1 = \lambda\left\{(3 - 2\sigma)a^2_1 - (x^2 + y^2)\right\}.$$

$$f_1 = \lambda\left\{(3 - 2\sigma)a^2_1 - 3(x^2 + y^2)\right\}.$$

$$g_1 = o.$$

The maximum greatest principal strain is $e_1 = \lambda a^2_1(3 - 2\sigma)$, which occurs at any point on the axis of the shaft.

We notice that the greatest strain occurs in the section $z = z_1$, so that we may limit our inquiry to that section.

27. The greatest principal strain at any point due to the combined loads will not be greater than the sum of the greatest principal strains for each load at that point. Further, if the principal planes of strain due to flexure, torsion, and rotation are nearly coincident amongst themselves, we may regard the combined principal strains at any point as equal to the sum of the corresponding principal strains due to each load at the same point.

Let us take three cases in which the maximum principal strain (S) at any point is—

(I.) The sum (S′) of the maximum greatest principal strains at all points due to the separate loads.

(II.) The maximum sum (S″) of the greatest principal

strains at any one point due to the separate loads.

(III.) The maximum sum (S‴) of the corresponding principal strains at any point due to the separate loads.

Let the factors of safety in these three cases be indicated by Φ', Φ'', Φ'''.

By examining the strains at various particular points due to the separate loads, we find

S' is $\mu a_1 z_1 (l - z_1) + \frac{1}{2} \tau a_1 + \lambda a_1^2 (3 - 2\sigma)$.

Let us take S″ as the greater of $\mu a_1 z_1 (l - z_1) + \frac{1}{2} \tau a_1 + 2\lambda a_1^2 (1 - \sigma)$, and $\lambda a_1^2 (3 - 2\sigma)$.

Take S‴ as the greatest of $\mu\sigma a_1 z_1 (l - z_1) + \frac{1}{2} \tau a_1 + 2\lambda a_1^2 (1 - \sigma)$, $\mu a_1 z_1 (l - z_1)$, and $\lambda a_1^2 (3 - 2\sigma)$.

The values of the factor of safety are given by

$$E \Phi' S' = T_o ; \; E \Phi'' S'' = T_o ; \; E \Phi''' S''' = T_o .$$

Φ' is certainly less than Φ (the true factor of safety) for S′ is greater than S. In general Φ'', Φ''' will not be greatly different from Φ.

For a more accurate determination of the factor of safety the values of the various constants must be substituted in the expressions for the strains e, f, g, a, b, c, and e_1, f_1, g_1 may be obtained as roots of a cubic equation. The maximum value of e_1, f_1, g_1 can then be determined. In a similar manner the factor of safety may be determined on the greatest stress theory, or on the greatest stress difference theory.

Thus on the maximum stress difference theory—which is gaining prominence in recent experimental work—let D_μ be the greatest stress difference at any point due to flexure alone, D_τ due to torsion, and D_λ due to rotation. Then it may be shown that

$$D_\mu = E \mu x z (l - z_1), \text{ if } z \text{ be large compared with } a_1 ;$$

$$D_\tau = \frac{E\tau}{1 + \sigma} \sqrt{x^2 + y^2} ;$$

$$D_\lambda = \frac{E\lambda}{1 + \sigma} \cdot \left\{ (3 - 2\sigma) a_1^2 - (x^2 + y^2) \right\}, \text{ if } \frac{x^2 + y^2}{a_1^2} < \frac{3 - 2\sigma}{3} ;$$

$$D_\lambda = \frac{2 E \lambda}{1 + \sigma} (x^2 + y^2), \text{ if } \frac{x^2 + y^2}{a_1^2} > \frac{3 - 2\sigma}{3} ;$$

and the maximum values of these may be investigated in the same way as has just been done for strains. Then $\Phi \times$ greatest stress difference due to combined loads = maximum allowable stress difference for the material.

In particular, if bending and twisting only be considered, the cubic whose roots are e_1, f_1, g_1 (the principal strains at $x = a_1$, $y = o$ due to the combined load) may be written, if z is great compared with a_1,

$$a^3 - a^2 \mu a_1 z (l - z_1) (1 - 2\sigma) - a \left\{ \mu^2 a_1^2 z^2 (l - z_1)^2 \sigma (2 - \sigma) + \tfrac{1}{4} \tau^2 a_1^2 \right\} - \mu\sigma a_1 z (l - z_1) \left\{ \mu^2 a_1^2 z^2 (l - z_1)^2 \sigma + \tfrac{1}{4} \tau^2 a_1^2 \right\} = o,$$

or,

$$\left\{ a - \mu a_1 z (l - z_1) \right\} \cdot \left\{ a + \mu a_1 z (l - z_1) \right\}^2 = \tfrac{1}{4} \tau^2 a_1^2 \cdot \left\{ a + \mu a_1 z (l - z_1) \right\} ;$$

so that

$$e_1 = \tfrac{1}{2} \mu a_1 z (l - z_1) (1 - \sigma) + \tfrac{1}{2} a_1 \sqrt{\mu^2 z^2 (l - z_1)^2 (1 + \sigma)^2 + \tau^2},$$

$$f_1 = \tfrac{1}{2} \mu a_1 z (l - z_1) (1 - \sigma) - \tfrac{1}{2} a_1 \sqrt{\mu^2 z^2 (l - z_1)^2 (1 + \sigma)^2 + \tau^2},$$

$$g_1 = - \mu a_1 z (l - z_1) \sigma$$

The principal stresses are $P_1 = \frac{E}{1 + \sigma} (e_1 - g_1)$; $Q_1 = \frac{E}{1 + \sigma} (f_1 - g_1)$; $R_1 = o$. At $x = a_1$, $y = o$ the maximum strain is e_1; maximum stress is P_1; and maximum stress difference is $P_1 - Q_1$.

To determine the bending μ_o that is equivalent to the bending μ and torsion τ combined, we may consider their equivalence dependent on their producing (1) the same maximum strain, or (2) the same maximum stress, or (3) the same maximum stress difference. We hence obtain

(1) $4 (\mu_o - \mu) (\mu_o + \mu\sigma) z^2 (l - z_1)^2 = \tau^2$.

(2) $4 \mu_o (\mu_o - \mu) z^2 (l - z_1)^2 (1 + \sigma)^2 = \tau^2$.

(3) $(\mu_o^2 - \mu^2) z^2 (l - z_1)^2 (1 + \sigma)^2 = \tau^2$

Or, if M is the bending moment, and H the twisting couple at the point considered, the equivalent bending moment M_o is given by

(1) $4 (M_o - M) (M_o + M\sigma) = H^2 (1 + \sigma)^2$.

(2) $4 M_o (M_o - M) = H^2$.

(3) $M_o^2 - M^2 = H^2$.

THE NEW CAPITAL OF AUSTRALIA.

ACCORDING to recent cables, and leaving out of account some formalities, we may now consider the question of the site for the capital of the Commonwealth as finally settled by the assent of the Senate. It may be remembered that the ultimate choice involved two decisions—first, as to the locality of the territory to be owned by the Commonwealth; and, secondly, the site within that territory, about as large as an English county, which was to be set apart for the city. About a year ago the first point was settled, and an article in our issue of January 8th last commented upon it. The Yass-Canberra district thus dealt with, was so called because the territory extended, roughly speaking, between two parishes, each having one of these names. The original proposal of the State Commissioner who reported on the question, was that the city should be at the Yass or north-west end of this area, owing, no doubt, largely to the fact that the main line of the railway—Sydney to Melbourne—ran through it. However, as pointed out in our article, this site involved an expensive water supply, and owing to investigations by the Rivers, Water Supply, and Drainage Department, which had been going on since 1906, a decision was arrived at to sacrifice the advantage of a main line connection in favour of a better site from the water supply point of view, at the Canberra or south-east end of the area. This, therefore, is the site which now has been finally approved by the Commonwealth Parliament.

THE NEW GERMAN STEAM BOILER LAW.

ON January 1st next a new law, regulating the installation of steam boilers, will come into force in Germany. This law, in comparison with the old regulations in force since 1890, contains many alterations of vital importance to builders and users of steam boilers.

One very important portion of the new law deals with the testing and inspection of plates, and is causing a good deal of anxiety to British firms who make boilers for export to Germany. Hitherto the certificate of the makers has been regarded as sufficient guarantee of the strength of plates, but under the new regulations examination and test must be made by independent experts recognised by the Federal States. At one time it was feared that this would mean that all boilers made for Germany would have to be constructed from steel made and tested in Germany; but representations have been made by the Agricultural Engineers' Association, and it seems not impossible that the German authorities will eventually decide to accept Lloyd's certificates under certain conditions. In any case, it is obvious that the new regulations must result in increased cost and trouble to the British manufacturer and hamper his trade with Germany, and in certain circles it is freely said that that is the intention of the law, and that eventually the Germans intend to prevent altogether the importation of foreign boilers.

Steam boilers are now divided into two classes—land and marine boilers. As the latter are of lesser general importance, most weight is given to the former; and we will confine ourselves to dealing with the alterations which have been made in the laws relating to land boilers.

"Land steam boilers" are held to be such fixed or portable boilers as are not only used on land, but also temporarily on buildings and constructions floating on or moving in water. Hitherto the regulations applied to all closed vessels which were used for generating steam at a higher pressure than the surrounding atmosphere, the only exception being low-pressure boilers, *i.e.*, boilers fitted with a device whereby the steam pressure in the interior of the boiler is prevented from exceeding a surplus pressure of half an atmosphere; these latter are still exempt from the new regulations, and so-called "dwarf boilers" are now also excepted. The latter, in the meaning of the Law, are steam generators whose heating surface does not exceed $\frac{1}{10}$ square metre, whilst the steam pressure must not be more than two atmospheres surplus pressure. They must also be provided with a suitable safety valve. Vessels in which steam taken from another generator is specially heated by the aid of fire (superheaters) are also not subject to the new regulations. Hitherto boilermakers have been left considerable latitude as to the selection of materials and dimensions; the new law, however, makes special provisions as to the stress to which the material is to be subjected, and stipulates for thorough tests of all the materials used in the construction of boilers. If the steam boiler be intended for a working pressure of more than ten atmospheres, no cast iron or malleable cast iron may be used in any part of the boiler walls, whilst brass is only to be used for fire tubes of not more than 80 mm. diameter outside. Hitherto it has been recommended that the flues of a steam boiler at their highest point should lie at least 10 cm. below the lowest appointed water level, but this distance has now been definitely fixed at 10 cm., and in the case of boilers the water surface of which is 1,3 fold of the total grate area, this distance must be at least 15 cm. As feed devices, two feeders have so far been required which were not dependent upon the same operative mechanism, so that each one could, if necessary, be used for feeding the boiler separately. By the new regulations these devices must be of such a size that each one shall be capable of feeding the boiler with double the quantity of water normally required. In the case of steam feed pumps, driven direct by the main steam engine, one and a-half times the normal evaporating capacity will suffice. Hand feed pumps are only allowed provided the product of the heating surface in square metres and of the steam pressure in atmospheres, does not exceed 120. One of the stipulated feed devices may be replaced by the direct use of a water pipe, if it be guaranteed that the actual pressure of the water service at the boiler is always at least two atmospheres more than the steam pressure permitted in the boiler. The lowest permissible water level, hitherto shown by a clearly visible mark, must now be marked by the inscription "Niedrigster Wasserstand;" in boilers with a heating surface of less than 25 square metres the letters "N. W." may be used for the same purpose. Fixed and portable boilers must be fitted with at least one and two safety valves respectively, spring and lever and weight valves being both admissible; in the latter case the pressure exerted on each valve must not exceed 600 kilos. The steam space of every boiler must be fitted with a pressure gauge, the dial being marked to indicate atmospheres. It must also be provided with a fixed conspicuous mark, clearly showing the maximum steam pressure; the movable indicators hitherto used are no longer allowed.

Steam boilers, to be erected at future dates, will not only be examined as to material and strength, but will also be subjected to a thorough internal and external inspection so as to determine if they have been properly built. The final inspection will be made under steam, and the officials making the trials must use an officially provided double manometer. Boilers for a working pressure of more than 6 atmospheres, and such in which the product of the heating surface in square metres and of the steam pressure in atmospheres exceeds 30, must not be erected below rooms which are often entered by human beings, nor above any rooms, excepting cellars. This stipulation does not apply to water-tube boilers, the tubes of which are seamless and have a diameter of 100 mm. outside, whilst the walls of the steam drum are not touched by hot gases. In this case the steam pressure must not exceed 6 atmospheres.

The new law renders things somewhat easier for so-called "dwarf" boilers, or those in which the product of the heating surface in square metres and the steam pressure in atmospheres does not exceed 2. For these one feed device is sufficient, no second watermark is required, and only one safety valve is necessary.

Boilers already in use and complying with the requirements of the old law, need not be altered to comply with the new stipulations until such time as they need a fresh inspection.

COMPULSORY WORKING OF PATENTS.

IN two recent cases the Comptroller-General has been asked to revoke patents on the ground of their not being worked in this country. The following is a summary of the facts and decision in each case.

In Knowles *v.* British Oxygen Company—decided on November 29th—the applicant sought revocation of a patent for the manufacture of an oxygen blow-pipe used for cutting plates of metal. The allegation was that the article was manufactured mainly or exclusively abroad. The patentees admitted that the manufacture at the date of the application was mainly carried on abroad; but they said that they could give satisfactory reasons for their inaction, and that there was at the date of the hearing a substantial manufacture in this country. The facts were briefly as follows:—The patent was applied for and granted to a Belgian company on December 29th, 1904, so that the right of the Court to revoke on the ground of non-working did not accrue until December 29th, 1908. From 1905 onwards the Belgian company made attempts to sell the patent in England. In November, 1908, it ordered six blow-pipes to be made and delivered by Aldous and Campbell, engineers, of Southwark. These were delivered early in 1909. In October, 1908, the Belgian company negotiated with Knowles for the purchase of the patent. Finally, on February 16th, 1909, it was sold by the Belgian company to the British Oxygen Company. The following points—*inter alia*—were relied on by the respondents: (*a*) that there were *bonâ fide* efforts to sell the patent in England; (*b*) that the restricted nature of the negotiations was due to the fact that the Belgium firm were anxious to sell the patent only to British firms who could control the supply of pure oxygen; (*c*) that the British Oxygen Company was an owner of plant, &c., which would enable it to carry on adequate manufacture; and (*d*) that at the actual date of the hearing it had in fact made more than thirty blow-pipes under the patent. The applicant relied on the fact that from 1906 onwards the process was exclusively used and advertised on the Continent, and that in reality there was no sale or manufacture in England.

The Comptroller, in giving his decision, said it was natural that the patentees should desire, if possible, to sell their patent to a firm which could guarantee the supply of pure oxygen in his country. This was not a mere blow-pipe, but a blow-pipe to be used in a specific process which necessitated the use of oxygen in its purest form to obtain the best results. It was right that the foreign firm should endeavour to get as high a price as possible from a British firm, inasmuch as the possession of the patent would afford an exclusive opening for the sale of oxygen. It was not disputed that there had already been a considerable manufacture of blow-pipes in this country. It did not appear that anything done had prevented or endangered manufacture of the article in this country. Indeed, that manufacture might benefit by the experiments made abroad, and by the experience gained by the use of the process in various manufactures. In the event the application was dismissed, the respondents being awarded £31 10s. costs.

With all respect to the Comptroller, it seems that in arriving at his decision he got somewhat far away from the language of the Act. Thus, we cannot see why the fact that the use of this particular patent may be useful to the business of one particular company should justify the foreign patentee in waiting until that particular company is prepared to pay his price. It should be mentioned, however, that the Comptroller went out of his way to indicate that many of the arguments advanced would have also supported an application for a compulsory licence, which the Court has power to grant if the reasonable requirements of the public are not satisfied.

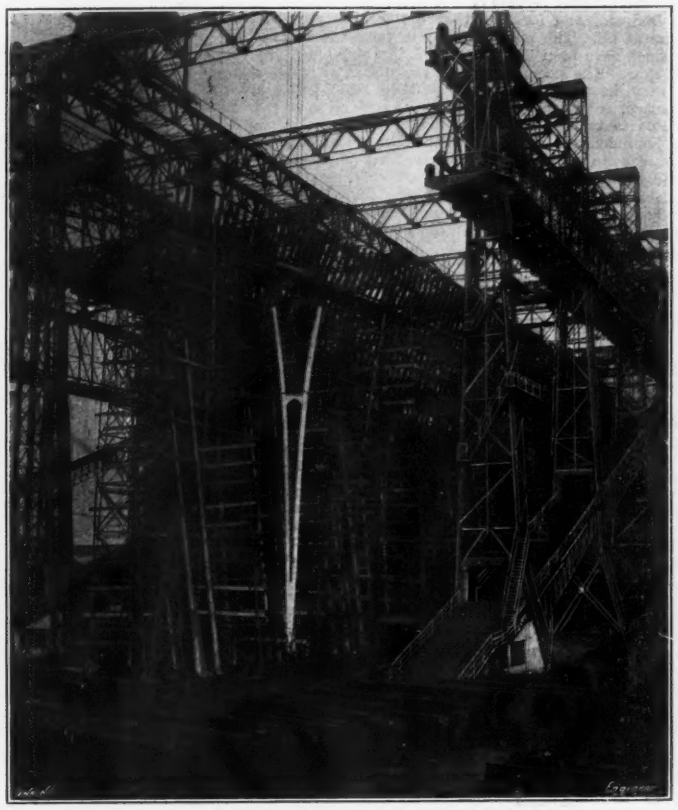
The next case to which we should like to refer is Jackson *v.* De Dion Bouton, in which application was made to revoke a patent relating to the valve of a motor engine. From the report which appeared in the *Times* of November 27th, it seems to have been admitted on both sides that the patent was of little commercial value, but the applicant desired revocation in order that he might get small De Dion engines from abroad. The respondents admitted there was no manufacture in England, and that they only sold motors imported from France. They contended that as the patent was useless, and as it could only be used, if at all, in connection with complicated engines, it would have been an unjustifiable expense to set up a factory in England in order to manufacture since August, 1908. The applicant alleged that the defendants were bringing actions for infringements in relation to the importation of motor cars containing this type of engine. The Comptroller, in the course of his decision, pointed out that according to the evidence of the applicant himself the demand here was really for the French-built engine, which was stated to be of very fine workmanship, constructed of excellent material, and it was, therefore, by no means certain that even if the demand for the patented article had continued it would not have been a demand confined to its construction in French engines and French engines only. He also said: "I think the fact that there is no demand for the patented article, and that it is considered as of little or no commercial value, must in almost every case be accepted as satisfactory reasons for non-manufacture. . . . I come to the conclusion with reluctance that I am unable to revoke the patent in question. Neither the present owners of this patent nor their predecessors have done much to help British industry. They have merely been the importers of cars made in France by the French De Dion Company, and they have used their patent rights here, not for the purpose of manufacture, but merely as a means of levying a toll on English purchasers." It is a little difficult to follow the reasoning by which the Comptroller arrives at the conclusion that lack of demand is such a justification of non-manufacture that it precludes a right to demand revocation. There may, as in this case, be a lack of demand for the engine by itself, but the holders of a patent for it may find it a very convenient means of preventing the use of motor cars which are driven by it. One would have thought that its being used in imported motor cars would be sufficient evidence that there was a demand.

THE NATIONAL ELECTRICAL MANUFACTURERS' ASSOCIATION.—The next committee meeting of this Association will be held at Balfour House, Finsbury-pavement, E.C., on Tuesday, December 14th, at 2.30 p.m.

BUILDING THE WHITE STAR LINERS OLYMPIC AND TITANIC

HARLAND AND WOLFF, LIMITED, BELFAST, ENGINEERS

THE SLIPS ON WHICH THE VESSELS ARE BEING BUILT—28th OCT., 1909



THE LAST FRAME OF THE OLYMPIC BEING LIFTED INTO POSITION—20th NOV., 1909

VIEW SHOWING THE OLYMPIC NEARLY FRAMED AND EARLY WORK ON THE TITANIC—18th NOV., 1909

THE WHITE STAR LINERS OLYMPIC AND TITANIC.

BY the courtesy of Harland and Wolff, Limited, we are enabled to give above three views showing the present condition of the two enormous liners, the Olympic and Titanic, which this firm is building for the White Star Company. The keel plate of the Olympic was laid considerably before that of her sister vessel; indeed, a commencement was made on December 15th, 1908, a good while before the gantry which has been specially erected for these two vessels, and which was referred to in the supplement to our issue of 18th June last, was completed. One of the views, which is reproduced from a photograph taken on November 20th, shows the last frame of the Olympic being lifted into position, so that the framing of this enormous ship took just eleven months and five days. Concurrently with the framing a large amount of other work has been carried forward. For example, the entire bottom and water ballast tanks are hydraulically riveted, and contain over half a million rivets. The plating of the sides is now well started, and good headway has been made with the decks and stringers.

The views we give speak for themselves, and require no special reference. The great usefulness of the gantry and its various cranes will be appreciated, and the light erecting pillars employed will be noticed. In the corresponding view to that showing the last frame of the Olympic, may be seen this vessel two-thirds framed and the water ballast tanks, &c., of the Titanic on the next slip. The photograph from which this engraving was reproduced was taken on October 28th last. This latter vessel would have been much further advanced than she is had it not been that there has been considerable delay in getting the large steel castings for her hull delivered. The largest view on the page gives perhaps a better general idea of the present condition of these two hulls than is given in the other two engravings.

TROUBLES IN AUSTRIA.

INDUSTRY and labour in Austria are suffering greatly from the parliamentary crisis. The obstruction of the Czechs having paralysed the activity of the legislature it has been impossible to vote the usual credits for State purposes, and the Government departments are consequently unable to give new orders for the coming year. The steel and iron trades are seriously affected by this condition of affairs, especially the locomotive and wagon works. Delegations of employers and workmen waited on the Minister of Finance a few days ago to urge the necessity of something being done to relieve the situation, but they were told that the Government could not give any new orders at present, though they might if they liked go on manufacturing engines and wagons at their own risk in anticipation of orders to be given later. Of the two branches the wagon builders are suffering most. Formerly the railways expended some twenty million crowns

a year—about £800,000—on cars, but when trade suddenly improved the demand went up to over two millions sterling. Now that the state has taken over all the big lines, with the exception of the Southern Railway, and there is a tremendous dearth of cars all the time, the manufacturers naturally expected larger orders, but they have actually been getting much smaller ones because of the unfavourable condition of the Budget. And for 1910 they are without any definite orders at all. The result is that in some cases half the workmen have been discharged and the remainder put on half time. The locomotive works are in slightly better case, as they have orders enough to keep them going until February, and by reducing the rate of production they may be able to keep their shops going for some weeks longer. The big industrial corporations generally are anxious to see parliament in working order again. They do not like dismissing workmen in the winter, not only because of the hardships inflicted upon the men and their families, but also because it reacts upon the numerous small tradespeople who are in their turn dependent upon the wages of the working classes.

WINDING ENGINE DESIGN.

A VALUABLE contribution to the proceedings of the Manchester Association of Engineers was made on Saturday last by Mr. G. James Wells, A.M. Inst. C.E., who read an exhaustive paper on the above subject. Starting with a supposed inquiry for a winding engine to perform a given duty, the author first went into the system of steam distribution, mentioning that the type of engine generally used is a two-crank compound engine, with cranks at right angles. The valve gearing must, of course, provide for the engine running in either direction, and since the engine must start from any position on full load, it is necessary to arrange for a very late cut-off with some means of increasing the amount of expansion when full speed has been attained. Most valve gears permit the cut-off to be as late as 80 to 90 per cent. of the stroke in full gear, but it is not easy to arrange for a cut-off at any point from zero to 90 per cent., including the ability to reverse the engine at full speed with a latest cut off in case of emergency. By means of diagrams Mr. Wells showed that there are four positions, or periods, in each revolution when only one cylinder is operative. With regard to the mechanics of winding the problem involves only the application of the simple principles underlying the starting of a mass from rest, accelerating it until a certain velocity is attained and then bringing the mass to rest again at the end of the wind. Under this heading the author showed by equations a convenient way to find a suitable rate of acceleration, or with a proposed rate of acceleration to find possible times for each period of the wind. This led on to a consideration of the design of drums, and the author here explained by means of a diagram how these should be constructed for the purpose of balancing. The simplest arrangement is to connect the two cages by means of a rope passing

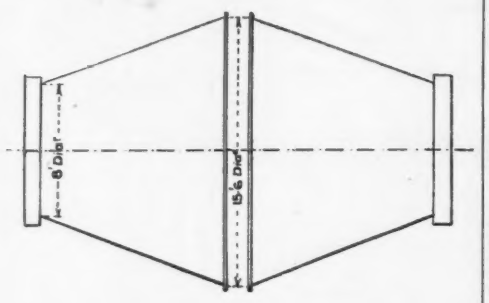


Fig. 1

down into the sump from one cage bottom up to the bottom of the other cage, so that the weight of rope hanging on each side is constant, while the static load is uniform and equal to the load lifted. A usual way is to modify the radii of the drum, so that at the start the loaded rope is at the small end of the drum, and the falling rope is on the largest diameter. The radii of the drum are so proportioned that the moments of the two ropes can be maintained fairly constant throughout the wind. This leads to a taper drum formed of two parts of two cones as in Fig. 1, their bases forming the middle of the drum. The dimensions of such a drum may be found by taking moments due to the rope pull at the beginning and end of the wind, remembering that the difference between these moments at each end of the wind must remain equal.

The author then demonstrated by graphical construction the effect of the continually changing radius of the drum upon the several items in the load imposed upon the engine. He also reproduced graphically a diagram showing the effects of inertia and resistance for this type of drum; and the effect of the pit-head sheaves. From the diagrams so produced Mr. Wells showed by a further graphical representation how the dimensions of the engine can be found.

The great expense and space occupied by the conical type of drum has led to the introduction of a compound type in which there is a smaller diameter parallel for the starting turns to be wound on, mounting up with a few spiral turns to a larger diameter upon which the last turns of the wind are received. This type increases the moment of the descending load and reduces the moment of the rising load, and so tends to reduce the inequality of the static load during the progress of the wind. The proportionate number of taper turns is a matter for judgment, and the examination of several ratios will serve to illustrate the effect of the varying the diameters, &c. A drum of this type is illustrated in Fig. 2. B B are the brake drums, A A are parallel portions, upon which a certain number of turns are wound at the commencement of the hoist, C C are the taper parts, upon each a spiral rope groove is fixed, guiding the rope up from A to D in a certain number of turns, and lastly D is a parallel part upon which the remainder of the turns are wound. There is obviously some difficulty in fixing upon the proportions of such a drum, for the variables are (1) the ratio of the diameters D and A, (2) the absolute diameters, and (3) the number of turns before commencing the climb from A to D. Of these the second is easiest to settle, because the life of the rope is in part dependent upon the amount of bending it receives, and in most cases the diameter A will be fixed at the minimum possible, which depends upon the size of the rope.

The Koepe system was next described. In this system the rope from one of the cages passes over the pit head sheave, thence round the engine pulley, over the second pit head sheave, thence to the second cage, whilst the two cages are connected by a balance rope so that the load upon the rope is constant throughout the wind. An objection made to the system in its original form was the risk of slipping, as with the cage resting on the stops the load was so reduced that the rope was too slack to give sufficient grip for the re-start. Re-capping the rope was difficult, and in case of rope failure both cages were free to fall. These objections, Mr. Wells said, have been met, but the system has not many examples in this country, though in Germany and South Africa it is more widely used.

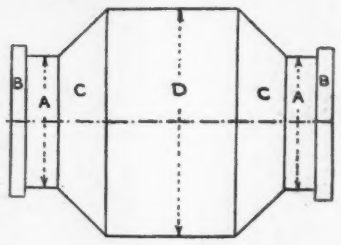


Fig. 2

The Whiting system was next described. This is like the Koepe so far as the single rope and the friction grip pulley are concerned, but two pulleys are employed in the Whiting system, each positively driven by the engine. The pulleys are placed tandem fashion, the spindles being coupled together like the driving wheel of a locomotive. The rope from the pit head sheave passes several times round first one and then the other winding pulley, thence under the engine to a tension pulley, back again to the other pit head sheave, to which it is led round suitable guide pulleys. The tension pulley has frequently a considerable travel, so that by its means some alteration of the levels of working can be readily made.

Another type of winding drum alluded to consists of two discs between which is wound a flat tape-like rope, the coils resting upon each other so that the drum diameter during the wind is continually becoming larger, thus increasing the moment of the rising load, whilst as the empty cage is falling, its effective moment is similarly decreasing. This is another device for obtaining the compensation necessary for equalising the static moment, and at the same time securing a minimum moment of inertia of the drums. In this system two drums are necessary, one for each cage, and a separate ring is frequently provided for the brake.

THE BIRMINGHAM ASSOCIATION OF MECHANICAL ENGINEERS.—The annual meeting of the Association will be held at the Grand Hotel, Colmore-row, Birmingham, to-morrow (Saturday) evening. The chair will be taken at seven p.m.

THE ROYAL METEOROLOGICAL SOCIETY.—At the meeting of the Royal Meteorological Society on Wednesday evening, the 17th inst., the president announced that the Council had awarded the Symons gold medal to Dr. William Napier Shaw, F.R.S., in recognition of the valuable work which he has done in connection with meteorological science. The medal will be presented at the annual general meeting of the Society on January 20th, 1910.

STUFFING-BOX PACKING.—A new kind of stuffing-box packing, which differs somewhat considerably from other forms, has been brought to our notice by the firm of Richard Klinger and Co., of 66, Fenchurch-street, E.C. It is made of a special material, of a soft, fibrous, and self-lubricating character, and is claimed to possess the highest heat-resisting qualities. We are informed that the process of manufacture is carried out on entirely original lines. The surface of the packing which comes into immediate contact with the piston-rod is provided with a lead grid, through which the correct amount of packing needed for making a tight joint is forced as the pressure is increased. This is claimed to ensure very regular and economical use of the packing. It is said to be suitable for any stuffing-box, and may be used with the highest steam pressures and degrees of superheat. The packing is coloured red on the side where the lead grid is situated, this, as stated, being the side which has to be placed next to the rod. The makers claim that, once the packing is placed in the stuffing-box, it never need be removed, all that is necessary to maintain a tight joint being to add a small quantity of new packing from time to time to compensate for the small quantity which disappears in working. This new packing, the makers state, combines all the advantages of metal and soft packings, and however much worn the piston-rod is, it will maintain a perfect joint. Judging from the sample which has been sent to us, we should say that it should prove effective, and should be capable of doing what the makers claim for it.

A NEW METHOD OF PRESERVING WOOD.—Some recent experiments by two Swedish engineers, MM. Heidenstam and Friedemann, on the preservation of timber, and in particular railway sleepers, have resulted in the introduction on a commercial scale of a new chemical preservative. The new substance is known as cresol-calcium, and is produced by the action of cresol—$HO \cdot CH_3 \cdot C_6H_4$—on slaked lime. A solution of the resulting compound having a 10 to 15 per cent. composition is used for impregnation, which is carried out in exactly the same manner and with the same apparatus as is employed for creosoting, with the exception that with the new material the temperature of 70 to 80 deg. Cent. required for the creosote process is not necessary. The advantages claimed for the method are its cheapness, the cleanliness of the treated material, and its inflammability. In addition, a feature of the process is said to be the ease with which the right amount of preservative fluid can be given to the wood. When dealing with creosote it is well known that much more has to be employed than is actually necessary from a bacteriological point of view. As for its preservative powers, we understand that tests have been, and are being, conducted by various authorities, and that the results so far compare most favourably with other processes. A feature of its action is the formation of a thin crust of chalk on the surface of the timber, thereby reducing the evaporation and loss by washing out which are met with in other cases. For this country Messrs. Blagden, Waugh and Co., 50, Lime-street, E.C., have been appointed sole agents.

AN INTERNAL COMBUSTION PUMP, AND OTHER APPLICATIONS OF A NEW PRINCIPLE.*

By MR. HERBERT A. HUMPHREY, Member, of London.

(*Continued from page* 564.)

Two-cycle pumps.—The pump so far described is what may be called a four-cycle pump, because there are two outward and two inward movements of the column of liquid in each complete cycle. It would clearly be advantageous to suppress the cushion stroke and the suction stroke, and so produce a two-cycle pump. We are familiar with two-cycle gas engines in which outside pumps are used to draw in the gas and air and to force them into the working cylinder. But the production of a two-cycle pump is arrived at without any such complication, since no outside pumps are required. Up to the present, four types of two-cycle pumps have been constructed, and of these the simplest to explain is that shown in Fig. 5, where A is the combustion chamber fitted with an inlet valve B for combustible mixture and exhaust valve C for burnt products. The bottom of the chamber is attached to a pipe having two branches D and E, and a single valve F which can close communication with either of the branches. One branch leads to a supply-tank containing water at a level $x x$, the other branch leads to the delivery pipe and the high-level tank, and is fitted with a water-valve G, which in this case is shown as closing a suction pipe dipping into a low-level tank H. When the valve F is in the position shown by full lines and the compressed combustible charge exists in the top of chamber A, explosion takes place and water is driven along the delivery pipe towards the high-level tank, the gases meanwhile expanding and imparting velocity to the column of water. When expansion has been carried to atmospheric pressure the exhaust-valve opens, and by this time the pressure on the left-hand side of valve F will exceed the pressure on the right-hand side, and the valve will swing across so as to open communication between the combustion chamber and tank J and to close communication

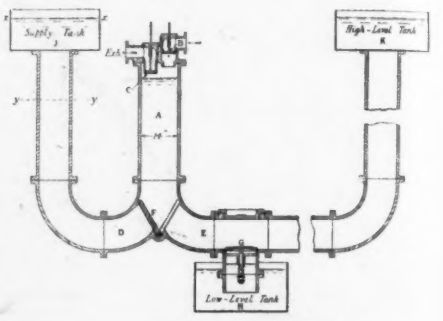


FIG. 5.—*Diagram of Two-Cycle Pump.*

with the delivery pipe. The moving column of water now has to entrain more water by sucking it up from tank H past valve G to follow the moving column. In the meantime, the water-level in the combustion chamber being considerably below the water-level in tank J, water will rise up in the combustion chamber, close the exhaust valve by impact, and cushion the burnt products imprisoned in the top of the chamber above this valve, until their pressure exceeds that due to the static head of the liquid in tank J. A reverse flow now occurs as the compressed cushion expands again, and a charge of combustible mixture is drawn into the combustion chamber. If there is still time for the action to take place, there will be a slight compression of the fresh charge by water again flowing from tank J into the chamber, but the main compression of the charge occurs when the column of water in the delivery pipe, having come to rest, returns, again closing valve G and forcing valve F from its dotted position back to the full-line position, thus giving free communication between the delivery pipe and the combustion chamber and closing communication with tank J. When the water column has been brought to rest by expending its energy in compressing the charge, a spark at the ignition plug ignites the charge and a fresh cycle is started. It is not necessary that the level of the water in tank J should be above the exhaust valve, because if it is at a level $y y$ the oscillation which takes place from the tank to the chamber may still carry it far enough up the combustion chamber to close the exhaust valve. The return flow, which draws in the new charge, will then be due to gravity as the liquid in the chamber tends to regain the level of the water in tank J. It is desirable that a pump so constructed should have a dashpot to control the movements of valve F, so that it comes slowly on to its seat in the dotted position and gives time for the water to be started in motion past valve G before communication with the combustion chamber is entirely cut off. If this valve is also controlled in its action of closing on its other seat, it may be arranged that the quantity of water which escapes past the valve back to tank J shall be equal to the quantity of water which moves from tank J to the chamber, and in this case the whole of the water delivered is drawn from tank H, and the returning column in the delivery pipe will then acquire a higher velocity than it would otherwise attain and thus give a higher compression pressure.

A modification of this pump is shown in Fig. 6, which simplifies

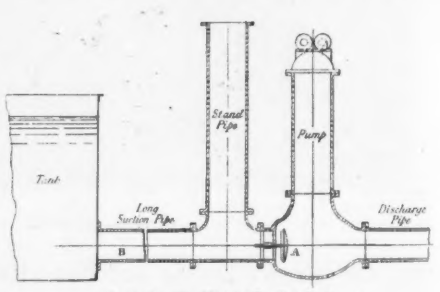


FIG. 6.—*Diagram of Modified Two-Cycle Pump.*

the arrangement and permits the use of only one water valve. In this case, between the supply tank and the combustion chamber there is enough pipe to give a certain amount of inertia, and on this pipe is a stand pipe, open at the top, up and down which the water oscillates. Suppose that explosion and expansion have occurred and water is being drawn past valve A. It is clear that the supply will be drawn from the source which offers least resistance, so that the water contained in the stand pipe will first flow past valve A to be followed by water from pipe B so soon as the greater inertia of this mass allows it to flow forward. When, however, the water in the pipe B has once been set in motion, its momentum keeps it moving, although valve A may be shut, so that it causes the level to rise in the stand pipe even above the level

* The Institution of Mechanical Engineers.

of the water in the supply tank. This brings about a condition of affairs in which, when the water valve A again opens, the level of the water in the stand pipe is considerably above the level of water in the combustion chamber. A quick rush of water therefore takes place, and the oscillation carries the water up the combustion chamber to close the exhaust valve. The necessary supply for this having come from the stand pipe, its level is lowered until it is below the exhaust valve, and consequently gravity causes the level of water to fall in the combustion chamber and so draw in a fresh charge while the column of water in the discharge pipe is still moving outwardly. The return of the column from the discharge pipe closes valve A and compresses the new charge ready for a fresh cycle.

Passing over a large number of modifications of the types of pumps so far dealt with, we come to a pump having two chambers in which the explosions take place alternately. A diagram of this arrangement is shown in Fig. 7, and one of its chief differences from the other pumps is found in the fact that the introduction of the combustible charge does not depend either on cushioning or on an oscillation of the kind described. Both chambers are fitted

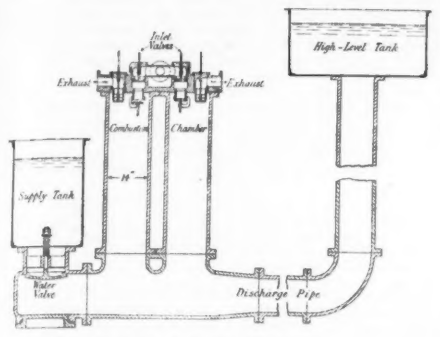
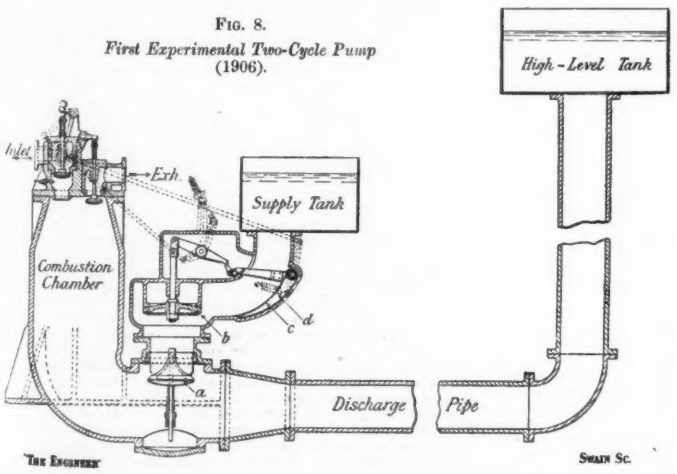


FIG. 7.—*Diagram of Double Barrel Two-Cycle Pump.*

with the usual inlet and exhaust valve, but a single water valve suffices to supply both chambers. Suppose all the valves are shut and that in the first chamber there exists a compressed combustible charge and that the second chamber is full of water. Explosion occurs in the first chamber and water is driven downwards and outwards from this chamber towards the high-level tank. As the gases expand a pressure is reached which can no longer sustain the water column in the second chamber, so that the water level in this chamber falls and a fresh charge is drawn into this chamber. When expansion is completed we have, therefore, burnt products in the first chamber, a fresh charge in the second chamber, and water at a higher level in the supply tank than in either of the chambers. Consequently water flows from the supply tank towards both chambers and partially clears the first chamber of burnt products by rising to nearly the level of the water in the tank. Water has been entrained through the water valve to follow the column of water flowing towards the high-level tank, and as this column comes to rest and commences to return again, it closes the valve and flows mostly into the first chamber from which the burnt products have a free exit past the exhaust valve. As the water reaches the exhaust valve, and shuts it, it finds only a very small cushion space in the top of this chamber, and its flow in this direction is therefore almost immediately arrested, so that the energy of the returning column is now obliged to expend itself in compressing the combustible charge in the second chamber. When this compression is complete and the water once more at rest, the cycle is ready to be repeated by an explosion occurring in the second chamber. It will be noticed that when compression occurred, the returning column had already moved some distance while exhausting products from the first chamber, and, therefore, it had an initial velocity when starting compression, which causes the maximum pressure reached with this pump to exceed the compression pressures attained with the same head of water in the other types of pumps. This pump is, therefore, suitable for low lifts where high compression pressures could not otherwise be obtained, and the gear required to operate

FIG. 8.

First Experimental Two-Cycle Pump (1906).



the valves, although interlocking, is quite simple. A very powerful suction stroke is obtained in this pump, because there is a tendency to draw in a charge of combustible mixture equal in volume to that of the expanded products. Considerable throttling is therefore necessary, and it is very easy to work this pump on a small suction-producer plant offering high resistance to the passage of gas. It should be stated that this pump ran perfectly well at the very first attempt to start it.

The first pump invented and tested by the author was not one of those so far described, but was a two-cycle pump of more complicated construction. There were, as shown in Fig. 8, two water valves *a* and *b* in the supply pipe, one of which *a* was an ordinary mushroom valve normally held closed by a spring, and the other a valve actuated by trip-gear when the velocity of the inflowing water reached a certain pre-determined amount. The point of tripping was controlled by balancing the centrifugal force of the water flowing round a bend and acting upon a curved plate *c* against a spring *d* which tended to pull the plate into the stream lines. The trip-gear was also utilised to open and shut the inlet and exhaust valves on the top of the combustion chamber. The action of this pump is as follows:—When the column of water in the discharge pipe has returned to give the compression stroke, valve *a* is shut and valve *b* is open. Ignition now occurs, and the water is forced downwards and outwards from the combustion chamber so that the column of water attains velocity, and as the expanded masses approach atmospheric pressure, valve *a* opens and water is entrained to follow the moving column towards the high-level tank. Some water also flows into the combustion chamber and discharges the burnt products. The rush of water round the bend in the supply pipe forces the curved plate into the recess, sets the trip-gear, and opens the exhaust valve, thus allowing the inflowing water to drive out the whole of the burnt products. When, however, the velocity has diminished so that the curved plate can be pulled out by the spring, valve *b* is dropped and the water supply is cut off. At this time, however, the outwardly moving column has not come to rest, so that its further movement may be utilised to draw water from the combustion chamber. This in turn will cause a new charge to be drawn into the chamber until the column of water ceases to move. The return flow now commences and valve *a*, in shutting, opens valve *b*, compression occurs, and the cycle is ready to be repeated. The cycle of this pump is as theoretically perfect as any of the others, but difficulties were encountered in obtaining uniform working and the experiments on this type were abandoned.

Pumps for high lift.—When it is desired to lift water to a height exceeding the head equivalent to the mean pressure of the indicator diagram, an attachment is added at the end of the discharge pipe, as shown in Fig. 9. This addition may consist of a small air-

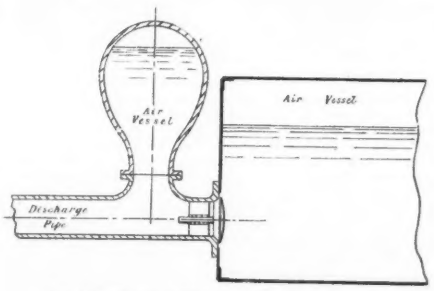


FIG. 9.—*Addition at end of Discharge Pipe when high lifts are required.*

vessel, placed at the end of the discharge pipe close to the large air-vessel into which the high-pressure water is to be delivered. The inlet into the large air vessel is fitted with a non-return valve, and the action, when working in conjunction with a two-cycle pump, is as follows:—When the explosion occurs in the pump chamber the water is forced along the discharge pipe and rises in the small air vessel, gaining velocity and compressing the air therein until the rise in pressure is sufficient to open the valve. The energy of the water column is then spent in delivering water into the larger vessel, and any backflow from it is prevented by the valve closing. There is now sufficient energy stored in the compressed air in the small chamber to produce the return flow of the column towards the pump required to compress the next combustible charge; then the whole operation is repeated. The amount of air in the small vessel has to be adjusted according to the pressure in the large vessel, and the air may expand below atmospheric pressure on the return stroke.

Pumps as air compressors.—The extreme flexibility of the author's system is shown by the readiness with which it can be adapted to the case of compressing air. The column of liquid which reciprocates backwards and forwards from and to the pump can be made to enter an air compressor chamber, fitted with suitable valves, attached to the end of what has so far been called the discharge pipe. The energy of the moving column of water is utilised to compress air, and also to store sufficient energy in an elastic cushion to produce a return flow towards the pump to give the compression stroke. This movement of the column also serves to draw a fresh quantity of air into the compressor. The action may be seen from the diagram of Fig. 10, where, for the sake of variety, the air compressor is shown attached to a four-cycle pump. The pump chamber A is connected to the compressor chamber B by means of the pipe C, and the quantity of reciprocating water is such that when the level is high in the pump chamber it is low in the compressor chamber. The air compressor chamber is fitted with an inlet valve D, an outlet valve E, and two other valves F G, which normally remain open under their own weight, and are so placed and constructed that they allow air to pass them, but not water, since the impact of the latter is sufficient to close these valves. Imagine that there is the usual compressed combustible charge in chamber A and a charge of air at atmospheric pressure in chamber B. Ignition occurs in chamber A and drives outwardly the column of water, so that the level rises in chamber B. Valve G, being open, allows air to escape to atmosphere while the gases are expanding and imparting kinetic energy to the moving column, but as soon as the level of water reaches the bottom of pipe H, which projects into the chamber, the water, trying to rise in this pipe, shuts valve G. The remaining air then suffers compression until the pressure at which the air is discharged is reached, when valve E opens and air is delivered under pressure. Next, the water reaches the level of pipe J, and, in attempting to escape with the air, shuts valve F. There being no further outlet, the imprisoned air is cushioned and the water column brought to rest. The cushion now expands again and gives a reverse flow which drives out the products of combustion from the pump chamber, gives the cushion stroke in that chamber, and causes the cushion expansion and suction stroke which follows. All that has happened in the compressor chamber is that the water level falls, air is taken in and suffers compression again, but not to the extent which causes any air to be discharged. The pressure reached, however, is sufficient to give a second return flow and compress the newly drawn in combustible charge in the pump chamber, and the cycle is ready to be repeated. As the water level falls in chamber B, valves F and G fall by their own weight. It will be observed that by altering the extent to which pipe H, projects into the air-compressor chamber the quantity of air acted upon may be varied, and this forms a ready means of adjusting the work of the compressor to deliver a greater quantity of air at a less pressure or a less quantity of air at a greater pressure. Greater elasticity in meeting all possible conditions is provided in the case where water may be taken in or discharged at valves placed one close to the pump and one close to the compressor, but it would occupy too much time to deal with the very large variety of air compressors which the author has invented in connection with his pumps. Naturally, the two-cycle pumps are better suited for this class of work than the four-cycle pumps, and it should not be overlooked that as there is no solid piston the space in the top of the air-compression chamber may contain vertical sheets of wire gauze which hold water and present a very large contact surface for cooling the air, and rendering the compression almost isothermal. The water which abstracts the heat does not remain in the chamber, for, in the case cited, where water valves are used, water is taken in and discharged at each cycle, and an

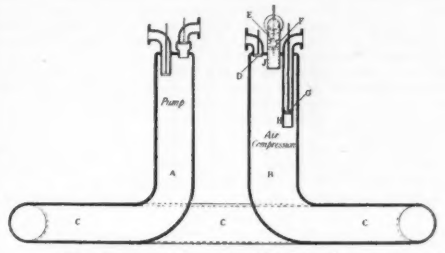


FIG. 10.—*Diagram of a Pump used for driving an Air-Compressor.*

automatic circulation through a cooling tank is set up. It is only necessary to make the tank of sufficient capacity to effect the required cooling.

(*To be continued.*)

LETTERS TO THE EDITOR.

(*We do not hold ourselves responsible for the opinions of our correspondents.*)

THE LATENT HEAT OF STEAM.

SIR,—I am sorry that Mr. Royds thinks the publication of his calorimeter tests will serve no useful purpose, as, without this information, it is not possible to judge the trials fairly.

Mr. Royds concludes from the trials that it is possible by oiling to reduce an engine's steam consumption by 15 to 16 per cent., but unless it is known with absolute certainty that no other condition changed, except the oiling, this is purely an assumption.

I hope he will reconsider his decision, as I can see things in Table II. which make me strongly suspect that the steam was wetter in some trials than in others.

If calorimeter tests are relied upon in important trials of this description, the question as to whether the latent heat of steam is a variable or a constant is of vital importance. If the latent heat of steam is accepted as a constant, then 1 lb. of saturated steam at above atmospheric pressure contains more heat than is at present believed. From this it follows that if the wetness of the steam is calculated from the present steam tables, the amount of water in the steam will appear less than it actually is if the latent heat of steam is accepted as a constant.

I have some evidence that, under favourable conditions, and especially with small engines, it is possible for a small change in the wetness of the steam at the engine stop valve to make a large change in the engine's steam consumption without the metal of the engine having anything to do with it.

The question of steam wetness, I feel sure, requires investigation, as I am confident that the wetness of the steam with different types of boilers, with boilers of the same type, and even with the same boiler under different conditions of working, varies to a much larger extent in ordinary practice than is at present realised, if the boiler has no superheater.

I also believe that the steam having varied in wetness explains the anomalies Mr. Wilkinson noticed in the interesting experiments described in the discussion on Professor Dalby's paper on "Heat Transmission."

As regards Mr. Royds' advice to consider the latent heat of vapours produced from other liquids, I have given hours and hours to the question; possibly Mr. Royds can help me out of my difficulties.

I believe I have seen somewhere that the latent heats of ether, chloroform, &c., at pressures above atmospheric pressure were not arrived at by actual measurements, but by calculations based upon absolute zero temperature and the critical temperature, both of which had previously been calculated from Régnault's steam experiments. But before these calculations were made the latent heat of these vapours was measured by actual experiments at atmospheric pressure, the method used being the same as Despretz used for steam.

Although I have searched carefully, I cannot again find this statement. Can anyone help me to do so? I have also searched for any information as to whether actual measurements of the heat contained in these vapours at high pressures have been made, but I can find no trace of this ever having been done.

If Mr. Royds knows of any actual measurements of the latent heat of other vapours than steam at above atmospheric pressure, will he kindly tell me where to find a description of them, as the whole question turns upon the method employed? Was the heat in saturated vapour measured, or was the heat in superheated vapour measured? Régnault measured the heat in superheated steam produced by wiredrawing saturated steam. Southern measured the heat in saturated steam. Southern, therefore, measured the latent heat, but Régnault did not.

FRANK B. ASPINALL

London, S.E., November 27th.

CENTRIFUGAL FORCE.

SIR,—The main difficulty of "Pater," "X.," and other of your correspondents seems to be that the force acting upon the stone accelerates, and yet does no work on it. It is forgotten that there is just as much deceleration as acceleration. The string is, in fact, a restraint upon the free motion of the stone in a tangential direction. The inertia of the stone is balanced by the tension of the string. Force, velocity, and acceleration are all vectorial or directed geometric quantities, whilst work or kinetic energy is a scalar or arithmetical quantity. "Pater" objects to cutting up the time or space of action of a force into small parts. Then let us take a whole revolution. In a whole revolution the total product of centripetal force and time acting on the stone—or of centrifugal force acting on the central attachment of the string—is zero, because the force has acted equally and for equal times in all directions, and so cancelled itself. How, then, can it have done work on the stone, or whither should the stone be accelerated? Or take a quarter of a revolution, say, from N. to E. The stone at N is flying eastwards with the velocity of X feet per second, and with zero velocity southwards. On arrival at E it is flying southwards with the velocity of X feet per second and with zero velocity eastwards. That is, it has been accelerated from O to X feet per second southwards, and decelerated from X to O feet per second eastwards. There is always this equality of acceleration and deceleration, hence no work is done on the stone by the centripetal force acting on it, and the kinetic energy remains unchanged.

But assume that for some reason kinetic energy is regarded directionally. Suppose Goliath is advancing from due south upon David, sling in hand. Then the only direction in which the kinetic energy has any value for David is southwards. The eastward directed motion of the stone at its N. position is useless, for it

has zero southward kinetic energy. But at its eastward position its whole kinetic energy is southward, and available, and the amount of it is that due to the centripetal force acting on the stone for a quarter of a revolution, reckoned southwards, *i.e.*, from its maximum value at N. to zero at E. The supposed revolution of the sling in a horizontal plane is not believed to be the orthodox method of slinging.

Looking at it another way, there is no force acting on the stone along its circular path. Therefore it is not accelerated in that path. There is always a force acting on the stone at right angles to its instantaneous direction of motion, and it is always altering its direction of motion—*i.e.*, being accelerated—in obedience to that force. Where is the difficulty?

When a force is balanced by the inertia of a mass, the mass is being accelerated by the force. But the inertia of the mass is a function of the acceleration, so that although the forces are in equilibrium, the mass concerned is not so, but is suffering acceleration or deceleration.

It may help your correspondents if they will consider the forces acting on a railway vehicle or a motor car as one or the other runs at a steady speed on a circular rail on a banked track.

London, November 27th. HENRY M. SAYERS.

SIR,—I have read with great interest the discussion that has been going forward in your columns in connection with the above question, and I note that none of your correspondents have any difficulty in proving that if the string is cut the stone will fly off at a tangent. The consideration of work done upon the stone is at once more interesting and more difficult, and carries us into the deep waters of ambiguity. Indeed, a study of the question would seem to show that the standard definitions of acceleration, force, &c., are either fallacious or incomplete. For in the case of the stone and string rotating in the same horizontal plane we have a uniform acceleration towards the centre produced by two equal and opposite forces, which is impossible. Also to accelerate a mass we must have a force acting through a distance, or work done, and so we have two balanced forces doing work, which is again impossible. Hence it would seem that there is no acceleration of the stone at all; yet there is change in direction of velocity, which is acceleration, according to the accepted definitions. What conclusion is one to come to save that the definitions are wrong somewhere? It seems, too, we should have some means to differentiate between change of linear velocity and change in direction of velocity, for surely the two things are distinct, and subject to different laws? But the question is outside my weight, and I must leave its solution to more mathematical readers. LUNDIN.

SIR,—May I suggest that the difference between "Pater" and your correspondents is that he regards acceleration as a change of velocity, whereas they take it as a change of direction. The stone has a constant velocity, but it is always changing its direction, and is therefore always being accelerated. Possibly a development of this idea of acceleration by change of direction would settle the whole matter.

November 30th. H. G.

THE GAS PUMP.

SIR,—Those of us who regularly turn to your pages to quench our thirst for wisdom in matters engineering found a sparkling and refreshing draught in your leading article under the above title. If, Sir, you found reason to suggest the presence of oxygen during the discussion on my paper last Friday, then surely there was ozone in the atmosphere around the editorial chair when you penned the humorous and instructive leader on the gas pump. We welcome such occasional unbending from the full-robed dignity and responsibility which usually attaches to your editorial columns, but in this particular case it has had one unfortunate consequence—the genial effect of the ozone has led you to accept from Mr. Henry Davey a theory which, under ordinary circumstances, you would have first examined for yourself.

Mr. Davey's theory is that, for a discharge pipe of uniform diameter and divided into horizontal and vertical portions, and with a water velocity limited to 10ft. or 12ft. per second, the horizontal portion of the pipe must be three or four times the length of the vertical portion.

Now, Sir, I absolutely deny the existence of any such theory, and I must characterise as absurd the lengths of pipe Mr. Davey has so obligingly calculated for me. In my reply to the discussion I shall deal with this subject, and my excuse for writing you now is that wherever your valuable journal travels it may at once carry this denial with it. If my pump required 600ft. to 800ft. of delivery pipe for a 200ft. lift, as Mr. Davey states, it would indeed be a serious drawback to its use. As I am satisfied with a tenth part of that length, excluding the rising main in which the flow is continuous, you will see the necessity of contradicting Mr. Davey's statement.

Turning for one moment to Mr. D. H. Irwin's letter in your last issue, I do not propose to quarrel with the figures he gives. As a director of Messrs. Crossley Brothers, Mr. Irwin has recently sold me three gas engines of the "most modern type with all recent improvements," and the best consumption he will guarantee is $\frac{3}{4}$ lb. of anthracite per brake horse-power hour at full load. From many actual results I believe this to be a fair figure. Now, if Messrs Crossley Brothers can develop a pump horse-power hour for 0.64 lb. of coal, as Mr. Irwin states, may I not reasonably inquire why they cannot at least guarantee the same figure per brake horse-power hour? They would still have all the margin between the pump horse-power and the brake horse-power in hand to play with.

London, November 29th. H. A. HUMPHREY.

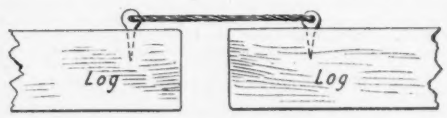
PRIMITIVE ENGINEERING BY CANADIAN LOGGERS.

SIR,—I think the following account of a primitive oil marine engine will interest your readers, but first let me give you a rough idea of a logger's cabin and his life, and then you will more readily understand the difficulties in making the boat that I have very feebly described. The logger is naturally a strong, hardy man, and has to rough it in his camp. He gets his three meals a day, and splendid food at that, but very little variation, pork and beans being the principal dainty, and appearing at every meal, served on tin plates, with green tea without milk, also in tin plates but of a deeper variety and free from any enamel ornamentations. His bed consists of three blankets, fairly large, one half of which is used to lie on, the other half being drawn over for covering. His coat is used as a pillow when neatly rolled up.

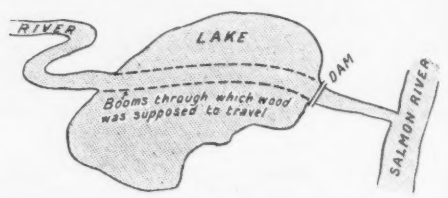
During the whole time the lumber is being drifted down a stream by the water current or by the gasoline tug where the current is not powerful enough, the men are constantly in the water up to their waists—no specially adapted clothes are used—nor does the logger put dry clothes on when he finishes work at the end of the day. He has his supper, sits by the kitchen fire for an hour or so, and then tumbles into bed with his wet things on, leaving them to dry on him during the night, and he is never any the worse for it.

The contract we had in hand was 4000 cords of pulp wood, chiefly cut in 4ft. lengths; but a large quantity of wood in full lengths of the tree had to be floated down a river 2½ miles to a lake made by a 9ft. dam, along the lake about five miles to the dam, and then two miles down the river to the main salmon river to Scotstown, where the mill was situated.

The original idea was to place trees or booms—that is, trees cut down and tied together by dogs connected with a chain or wire thus—along the lake to keep the wood from drifting in all direc-

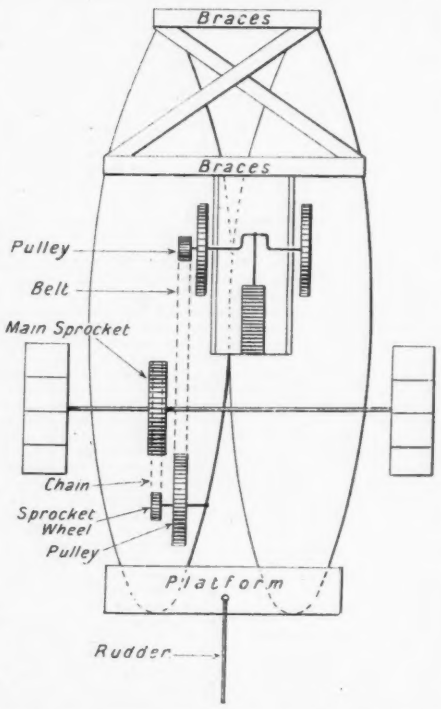


tions; then open the dam gates to make a current, and the pulp wood was expected to drift down over the dam and into the salmon river, *i.e.*:—

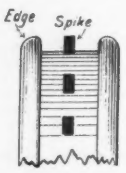


Unfortunately, the dry season caused a loss in water power, and when the booms were full a gale sprang up which broke them and sent the pulp wood in all directions in the lake in amongst the birches and tall weeds. The only thing to do was to place a boom across the river to prevent more wood coming down into the lake, and make a tug out of any material at hand, so that the pulp wood could be floated into a cage or raft by using the booms, and let the tug drag the rafts across the lake to the dam, where the raft could be opened to let the wood out of the booms and the tug taken back for another load. Well, a stationary gasoline engine was found near at hand, used by a farmer for threshing and pumping. Two of the boats were braced together to take the weight, and old material out of the mill was used to form paddle wheels and the balance of the machinery. The logger's chief tools being an axe and a cross-cut saw, you can understand what sort of a job was made. I give you a sketch of the vessel.

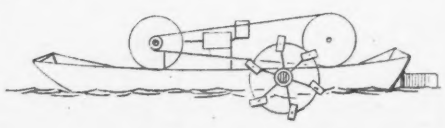
The boats were each 30ft. by 5ft. 9in., and were braced together



by boards in front and the platform for the engine. The main sprocket wheel was a wooden pulley, with large spikes nailed on to act as cogs for the chain to grip on, and had a bead of wood nailed on the edges to prevent the chain from sliding off the sides, thus:—



The pulley on the engine was 1ft. 5in., the main pulley 3ft. 10in., the sprocket wheel 11in., main sprocket 3ft. 5in., paddle wheels 5ft. outside measurement.



The engine was 6 horse-power, horizontal stationary, International Harvester Company's gasoline, with auto sparker, water cooled.

Absence of covering for the engine in wet weather caused the belt to slip and fall off, water in the gasoline stopped the engine, and so on until it became a positive work of art to keep the boat going. To make matters worse, the chain did not fit the sprocket wheel, and was constantly breaking and needing new links. Furthermore, there was only one speed at which the engine worked, and no reverse, hence a good deal of skill in steering and judgment of distance were demanded. Only once was the engine cleaned during the two months I had it, for it was generally on the go all through the working hours, and if we did shut her down it was to release me to give a hand at something else. The only cleaning it had that time was not thorough. The sparking plug got fouled, and, after being taken out and cleaned, soon fouled again, so I took out the piston-rod, and thoroughly cleared all deposits from the explosion chamber, and that was the only real time she refused me, but she was off again in two hours.

I trust these notes from the wild may interest some of your younger readers at least. G. A. W.

THE ECONOMY OF PUMPING ENGINES.

SIR,—In the course of the discussion which followed the reading of Mr. Humphrey's paper reference was naturally made to the economy of pumping engines. It is not easy to compare the fuel consumption of an internal combustion pump with that of a steam pump. It seems to me, however, that the latter was over-estimated. The following facts may be of interest at the present moment:—

In 1883 the first compound rotative pumping engines ever seen were designed by Mr. Edwin Reynolds, constructed and set to work to supply the city of Allegheny, Pa., with 5,000,000 gallons per day. There were one high and two low-pressure cylinders. They gave a duty of 110,000,000 per 100 lb. of coal. The pressure was 107 lb., and the piston speed 129ft. per minute.

In 1886 the Allis Company built to the designs of Mr. Reynolds the first triple-expansion rotative pumping engine. The pressure was limited to 80 lb.; the capacity of the plant is 18,000,000 gallons per twenty-four hours, lifted 160ft., twenty revolutions, 200ft. per minute piston speed; the cylinders are 28in. + 48in. + 74in. × 60in.—the cylinders are jacketed all over. The reported duty is 129,000,000, or 13.84 lb. of steam per indicated horse-power per hour.

The total cost of pumping 5,204,000,000 gallons per annum 160ft. high at Chicago is given at 7.34 dols. per 1,000,000 gallons, and for coal only 3.15 dols., coal costing 5.95 dols. per ton.

I can give many other examples, but these will suffice to show that the ordinary piston steam engine will require a great deal of beating.

The Davey differential engine is a machine of high efficiency if it is properly worked; that is to say, great care must be taken that it completes its stroke. I have seen one of considerable size working 10in. to 1ft. short at each end, and I have actually known this method of working to be adopted when there was not enough water to keep the engine properly loaded in a mine. The best results with any steam engine can only be got by intelligent management. It would seem that one advantage of the Humphrey pump is that no skill is required to work it.

November 29th. U. S. A.

TRANS-SIBERIAN RAILWAY.

SIR,—Under the heading "Railway Matters," the rumour is reproduced in THE ENGINEER from daily papers "that the Russian Government are about to conclude with a big American Syndicate for development of the Trans-Siberian Railway and laying of a second track." From reliable quarters in St. Petersburg I can affirm that the Russian Government have no such intention. "Russia for the Russians" is the axiom, and Government have to take into close consideration the critical state of Russian industry, lasting for several years. The "Douma" would have also to say a word in the case and strongly object, no doubt.*

London, S.W., November 30th. F. A. F.

INTERNATIONAL TESTING ASSOCIATION.—At a recent meeting of the British Branch of the International Testing Association, representatives to the following committees, already in existence, or about to be appointed, for the investigation of the problems specified were nominated:—A. Metals.—(*a*) Influence of slag enclosures. Mr. J. E. Stead, Dr. W. Rosenhain, Mr. E. F. Law, (new committee). (*b*) Determination of hardness by ball or cone pressure tests (existing problems 2 and 27). Proposed new committee for joint investigations:—Professor Unwin, Professor Goodman, Dr. Stanton. (*c*) Impact tests. New committee proposed:—Mr. W. G. Kirkaldy, Captain M. H. Riall Sankey, Mr. Bertram Blount, Dr. Stanton. (*d*) Method of testing cast iron (problem 25). Existing committee is to be dissolved and the problem to be referred to committee 1, to which it was recommended that the following names be added:—Mr. J. E. Stead, Mr. F. W. Harbord, Mr. W. G. Kirkaldy, Mr. E. Adamson. In connection with the formation of this committee it was further agreed to recommend that a sub-committee on cast iron be appointed. (*e*) Utilisation of magnetic and electric properties of material in connection with the mechanical testing thereof. New committee—appointment of nominees to be referred to the National Physical Laboratory. (*f*) Internationa. Specifications for Iron and Steel. Committee 1:—Mr. J. E. Stead, Mr. F. W. Harbord, Mr. F. E. Robertson. Committee 1A:—Mr. F. E. Robertson, Mr. Skelton, Professor Goodman, Mr. J. T. Milton, Captain Sankey, Mr. Stead, and a nominee by Mr. H. F. Donaldson and by Messrs. Vickers, Sons, and Maxim, respectively. The matter of making any further nominations representative of manufacturers was delegated to Mr. G. C. Lloyd. (*g*) Nomenclature of iron and steel (problem 24):—Dr. Rosenhain, Mr. F. C. Fairholme, Mr. L. P. Sidney. (*h*) Specifications for copper alloys (problem 38):—Dr. Glazebrook, Mr. F Tomlinson, Mr. Bertram Blount, Professor Gowland, Mr. J. T. Milton, Dr. Rosenhain, and a nominee of the Institute of Metals. With reference to the supplementary list of new committees, the formation of which is contemplated, the following recommendations were unanimously adopted:—New committees. Section A. Metals. (1) Investigation of copper steels and high-speed tool steel. To add Dr. H. C. H. Carpenter's name to the list. (2) Homogeneity of metals in relation to the microstructure. To refer this matter to existing committee for problem 2. (3 and 4) Impact tensile tests and resistance to alternating stresses. It was recommended that these two subjects should be treated together by the committee dealing with impact tests. (5) Influence of temperature in relation to working. The scope of this subject not being, in the opinion of the meeting, clearly defined, it was resolved to refer the matter to the council of the Association for further elucidation. Problem 43 would appear to deal with this matter. (6) Internal stresses. It was recommended that the proposal by Mr. Mesnager, as to the definition of terms, should be dealt with by the committee on nomenclatures. Section B. Cement.—(1) Cement tests. It was recommended that this matter should be dealt with by committee 41, the following names being recommended for addition to that list:—Mr. A. C. Davis, Mr. P. W. Meik, Mr. Bertram Blount. (2) Reinforced concrete. To add the following names:—Mr. A C Davis, Mr. P. W. Meik, Mr. Bertram Blount. (3) Plastic mortars (committee 42). Add Mr. Charles Watson, Dr. Desch, and R. Curling Styles. (4, 5 and 6) It was recommended that these subjects (Sec. B., Nos. *c*, *d* and *f*) should stand over. (7 and 8) It was recommended that this subject (standard cement, Sec. B, No. *g*) should be referred to committee 42, and further that to committee 30, on finest particles (Sec. B, No. *h*) should be added the names of Messrs. W. J. Cooper, C. W. Sharrock, and V. Earle. (9 and 10) It was agreed to recommend that these two subjects (Sec. B, Nos. *i* and *k*) the weathering of building stone and the weathering of masonry, should be treated together by committee 7, and it was recommended that the names of Mr. Brindley, Dr. Flett and Mr. Mumby be added to that committee. Section C. Miscellaneous.—(1) Wood tests. Mr. W. G. Kirkaldy and a nominee by the Post-office Department. (2) Protection of iron. Mr. Leonard Archbutt, Mr. Brodie, Dr. Rosenhain and Mr. J. Cruickshank Smith.

* The statement has now been officially denied by the Russian Government.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Steel.

THERE was a very quiet market on 'Change on Thursday in Birmingham as regards business, the chief topic of conversation being the political position. Semi-finished steel was in good request for the galvanised iron trade and for the tin-plate trade, both of which industries are flourishing. Bessemer sheet bars were quoted £4 15s., and Siemens descriptions an additional half-crown. In the structural steel trade several firms are well off for orders, whilst others are very poorly employed, there being considerable inequality. Mild steel engineering bars are quoted £6 7s. 6d. to £6 17s. 6d., angles £5 17s. 6d. to £6, and joists £5 15s. to £6. For boiler plates £7 5s. is asked.

Manufactured Iron.

Trade continues very quiet in manufactured iron in all branches except galvanised sheets and best bars. The quotation for the former remains £11 to £11 5s., and for the latter £8 per ton. Other departments are devoid of animation, with quotations unchanged on the week, but with a greater tendency by sellers to make concessions.

Pig Iron Dull.

Deliveries of pig iron are proceeding under old contracts, but new business is very scarce, and prices are weak. Makers quote cinder forge 45s. to 46s.; part-mine, 48s. to 49s.; best all-mine forge, 85s.; foundry, 90s.; and cold blast, 115s.

The Outlook.

It is not expected that business will change for the better until the New Year, some people cheerfully expecting a revival in the spring.

NOTES FROM LANCASHIRE.

(From our own Correspondent.)

MANCHESTER, Thursday.

Pig Iron a Declining Quantity.

THE attendance on the Manchester Iron Exchange on Tuesday was above the average. Actual business was, however, on a limited scale. As time progresses, it is quite evident that there will be no improvement in the current year, and this notwithstanding good reports of business for German and American account. There has been a gradual decline in warrant iron during the past week. In sympathy, Middlesbrough brands on spot have declined about 6d. per ton, and in some cases hematite has weakened to a considerable extent. Staffordshire and other sorts of pig iron have favoured buyers. Forge iron has been quiet. Beyond this there is no new feature to report.

Finished Iron and Steel.

The position remains practically unchanged. There has been no official change in prices, but merchants report actual business as exceedingly slow.

Copper.

The reduction in the raw metal has caused a corresponding decline in manufactured stuff. Sheets are £2 per ton lower, and ingots are in buyers' favour. We do not hear, however, of any reduction in tubes, although in some cases there was a tendency to book orders at ¼d. per lb. lower.

Lead and Tin.

Lead: Sheets quietly steady and unchanged. Tin: English ingots ruled a shade easier.

Quotations.

Lincolnshire No. 3 foundry, 55s.; Staffordshire, 53s.; Derbyshire, 55s.; Middlesbrough, open brands, 59s. 9d. to 59s. 10d. Scotch: Gartsherrie, 61s.; Glengarnock, 60s. 6d.; Eglinton, 59s., delivered Manchester. West Coast hematite, 61s. to 61s. 6d.; East Coast ditto, 60s., both f.o.t. Delivered Heysham: Gartsherrie, 59s.; Glengarnock, 58s. to 58s. 6d.; Eglinton, 57s. Delivered Preston: Gartsherrie, 60s.; Glengarnock, 59s. to 59s. 6d.; Eglinton, 58s. Finished iron: Bars, £6 10s.; hoops, £7 12s. 6d.; sheets, £7 12s. 6d. to £7 17s. 6d. Steel: Bars, £6 2s. 6d. to £6 5s.: Lancashire hoops, £7 5s.; Staffordshire ditto, £6 17s. 6d. to £7; sheets, £7 17s. 6d. to £8; boiler-plates, £7 5s. to £7 7s. 6d.; plates for tank, girder, and bridge work, £6 5s. to £6 7s. 6d.; English billets, £4 12s. 6d. to £4 15s.; foreign ditto, £4 10s. to £4 15s.; cold drawn steel, £9 10s. to £9 15s. Copper: Sheets, £72; tough ingot, £62 10s.; best selected, £62 10s. per ton. Copper tubes, 8⅝d.; brass tubes, 7½d.; condenser, 8½d.; rolled brass, 6½d.; brass wire, 6⅝d.; brass turning rods, 6⅜d.; yellow metal, 6⅛d. to 6⅜d. per lb. Sheet lead, £17 per ton. English tin ingots, £139 10s. per ton.

The Lancashire Coal Trades.

The attendance on the Coal Exchange was quite up to the average. Business generally was rather slow, the change in the weather having caused a diminution in the demand for house coal. The condition of the cotton trade is also causing a diminished demand for slack. At a meeting of Lancashire coalowners it was resolved that no advance should be made, a decision which will be met with approval on the part of consumers of house coal. In fact, it was felt that the advance of a couple of months ago in steam and manufactured coal was not justified by the trade passing.

BARROW-IN-FURNESS, Thursday.

Hematites.

There is no improvement to note in the hematite iron trade this week, and the report of business doing and of inquiries for prompt and forward deliveries is not encouraging for the moment at any rate, yet there is a good feeling in the market, and both buyers and sellers are looking for better times after the New Year has been reached. The production of iron is, however, greater than the sale of iron, and stocks in makers' yards are consequently increasing, but not to a large extent, and some of the iron going into stocks has already been sold, but is not wanted for consumption at present. There is no growth of stocks, however, in warrant stores; on the contrary, there has been a clearance of 300 tons, and the metal now held bulks at 18,331 tons, which is, after all, only a comparatively small holding. The demand for special hematite iron is fairly maintained, and the prices are quoted at 64s. to 65s. per ton, according to quality. Mixed Bessemer numbers are at 62s. 6d. nominally, but business has been done at from 61s. to 61s. 6d., while warrant iron is weaker at 60s. 3d. net cash sellers. Sales of ferro-manganese are well maintained, and there is still a steady demand for spiegeleisen. The make of iron is maintained, and twenty-eight furnaces are making iron. It is not probable that any reduction of output will be determined on at present, as it is expected that better times will be with us in the course of a few weeks. Iron ore is in steady demand, but there is most inquiry for best classes of metal. Prices remain steady at 12s., 14s. 6d., and 18s. net at mines for ordinary, medium, and best classes. Foreign ores are still being largely imported, and by this means smelters can best keep down the prices of native classes of ore.

Steel.

The trade being done in steel is rather better than it has been. The demand for rails is, however, not very pronounced either on home or on Colonial or foreign account, but makers are able to find employment for two-thirds of the mills in the district and it is expected that this condition of things will be maintained for two or three months to come. Prices are at present about £5 5s. per ton net f.o.b. for heavy rail sections. Nothing is being done in plates, and the demand for other classes of shipbuilding material is also quiet. No improvement in this branch of trade is expected until there is much more activity in the shipbuilding trade than at present. Merchant steel is in moderate request. There are prospects, however, of more briskness in the steel trade generally in the beginning of next year.

Shipbuilding and Engineering.

Shipbuilders are on the look out for new orders, and it is expected that before long they will book important work. Engineers are in much more busy times in all their departments, and even greater activity may be expected so soon as the orders recently booked are further forward than at present.

Shipping and Coal.

The exports of iron and steel last week amounted to 11,371 tons—iron 2975 tons and steel 8396 tons, as against 9187 tons for the corresponding period of last year, an increase of 2184 tons. For the year to date the shipments aggregate at 566,157 tons, against 458,277 tons for the corresponding period of last year, an increase of 107,880 tons. Coal and coke steady.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Business Position.

THE condition of trade all round seems one of "marking time." Quietude generally prevails, and there appears little prospect of any activity in our leading departments of local manufacture until, at least, the early period of next year. In the coalfield business is largely in a waiting attitude, the contracts for locomotive fuel having yet to be settled, as well as the bulk of the shipping contracts. The iron market continues featureless and dull, while the steel trades are not at all active, although the inquiry for crucible and tool steel for the United States and several other foreign countries is fairly well maintained.

Steam Coal: Contracts and Exports.

Tenders have recently been sent in for supplies of locomotive fuel in the case of the railway companies whose contracts expire at the end of the year. On the results will depend, to a considerable extent, the arrangements to be made with shippers. In the latter instance there is some movement, bunker coal order—a good weight—having been placed by the Cunard and Elder Dempster Shipping Companies. Some small shipping contracts are reported to have been made at from 9s. 3d. to 9s. 6d. per ton, the latter, it is understood, being the figure below which the collieries are not likely to go. As we pointed out last week, however, the prices received for "spot" lots are not to be taken as indicative of the rates that coalowners expect to obtain for next year's supplies.

House Coal—Higher Prices Talked of.

Business continues on the up grade, and further improvement is looked for as the holiday season approaches. Reports vary considerably, but stocks seem to be pretty well worked off, and this condition synchronises with better business at local depôts, as well as on distant account. Consequently, there is talk of a probable early advance of 1s. per ton, and 6d. per ton on nuts. So far, however, we cannot hear of any official step in this direction. Current quotations:—Best Barnsley, 12s. 6d. to 14s. per ton; secondary descriptions, 10s. 6d. to 11s. 6d. per ton. The firmer tone in domestic fuel noted last week in the West Yorkshire district is fully maintained.

Small Coal and Coke.

The situation in regard to slack continues as previously reported. Some considerable sales for shipment have curtailed stocks. Coking smalls firm and in good request. Smalls for Lancashire and Yorkshire mills, 4s. 6d. to 5s. 6d. per ton. Market for furnace coke well maintained. Best washed, 12s. 6d. to 13s. per ton; unwashed, 11s. 6d. to 12s. per ton.

The Iron Market.

Dullness still pervades the pig iron market. Deliveries, having regard to the state of trade, are fairly good. There is a general impression that prices of all irons will be dearer next year, owing to the increased cost of fuel; and ironmasters, therefore, are not disposed to give way in respect of forward contracts. Official quotations are unchanged, viz:—West Coast hematites, 68s. to 70s. per ton; East Coast, 65s. to 67s. per ton. Lincolnshire: No. 3 foundry, 52s. 6d. per ton; No. 4 foundry, 51s. 6d. per ton; No. 4 forge, 51s. 6d. per ton; No. 5 forge, mottled, and white, 51s. 6d. per ton; basic, 52s. 6d. per ton. Derbyshire: No. 3 foundry, 52s. per ton; No. 4 forge, 50s. 6d. per ton. The figures in every case are net, delivered in Sheffield and Rotherham.

Bars, Hoops, and Sheets.

Quotations as before, and business very quiet. Bars, £6 10s. per ton; hoops, £7 10s. per ton; sheets, £8 10s. per ton.

Steel, &c.

The most gratifying feature of the steel trade is in respect of crucible and tool steel. The improvement recently noted in the United States demand for tool steel, including the high-speed qualities, is fully kept up, and there is also an increased business reported with South America, Germany, and several other foreign markets. The principal demand is in the very best grades. The foreign trade, indeed, is fairly brisk, and if the home requirements were equally good, these departments would leave little ground for grumbling. Unfortunately, however, there are few signs of any immediate revival in the home markets. We do not hear of any fresh movements in regard to marine or railway material. An improvement in both departments, especially in railway steel, is confidently looked for next year. Military material is finding less employment, and new orders would be exceedingly welcome in the armour-plate and projectile departments.

Grinding Regulations.

Several of the new regulations dealing with the grinding of metals and racing of grindstones come into operation on the 1st of this month. The regulations enforcing the provisions of new appliances in factories are delayed by the Home Secretary until the 1st of June next year. Those regulations which have now come in force are of considerable importance to workmen, who will, no doubt, seek to make themselves fully acquainted with the new conditions imposed upon them, and failure to comply with which involves liability to penalties.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Pig Iron.

BUSINESS in Cleveland pig iron continues very slack; the prices have during the last few days declined rather smartly, and some of the traders are inclined again to be pessimistic; certainly the buoyant feeling that was reported a short time ago is hardly appreciable now, and consumers are disinclined to buy for next year's delivery. The action of the speculators is weakening the prices of warrants; they are losing heart, because their anticipations in regard to the American demands for Cleveland pig iron are not being fulfilled, and they are not prepared to keep the iron over the winter season when the expense of carrying it is so heavy. It may be that they will have to accept less for the iron in the early part of next year than the figures ruling now. They are therefore keen to sell without delay, and are bringing down prices by their pressure to dispose of their iron. Much depends upon how the American consumers in the Eastern States are placed. At present they can secure all they want from American ironmasters at prices which compare favourably with ours. It was chiefly the expectation of big American demands this autumn for Cleveland iron that led to the rise in prices that did take place, and, as the demand actually has been a very disappointing one, the speculators are depressing prices by their endeavours to get rid of the iron they bought. The market is weakened likewise by the bad shipments and the rapid increase in stock in Connal's public store. Consumers, therefore, believe they will find it to their advantage to wait, and thus buy from hand to mouth only. It is not usual for consumers to purchase heavily in a falling market, especially with the quietest time of the year coming on, and a general election in prospect. The prices of Cleveland pig iron are lower this week than they have been since the early part of August. No. 3 has dropped to 50s. per ton for early f.o.b. delivery, No. 1 to 52s. 3d., No. 4 foundry to 48s. 6d., No. 4 forge to 48s. 3d., and mottled and white to 47s. 9d., and the quotations for forward delivery are little better than nominal, because of the unsettled and uncertain state of the market.

Hematite Pig Iron.

Producers of hematite pig iron speak well of their business and its prospects, and certainly they are in a considerably better position now than are the makers of ordinary Cleveland pig iron. They can firmly maintain their prices, while those of Cleveland iron are falling. They have not to contend with the holders of warrants as the Cleveland makers have, because there are no East Coast hematite warrants now. Besides this, producers themselves have no stocks, and all they are making is going direct into consumption. All those who are consumers of hematite pig iron are well off for orders, and report trade prospering, and more particularly is this the case in the shipbuilding industry. Some of the hematite makers have already sold a good deal of iron for delivery next year, and thus further advances in quotations may be looked for. Mixed numbers with makers are at 60s. per ton for prompt delivery, and 62s. 6d. has been asked and paid for first quarter next year. Prompt parcels are heard of at 59s. 6d., but they are offered in special circumstances by second hands, who are compelled to sell. Rubio ore is nominally at 17s. 6d. per ton for prompt c.i.f. delivery Tees, but there has been no business to fix the prices actually. It is still impossible to give any reliable information about the forward prices of ore. Furnace coke is firm at 17s. 6d. per ton, delivered at Middlesbrough works promptly, but manufacturers will not take as little as this for next year's delivery. The production of coke is not in excess of requirements, and the home consumption has lately been increased, as also have the exports.

Stock of Pig Iron.

The rapid increase in the stock of Cleveland pig iron in Connal's public store cannot be described otherwise than as an unsatisfactory feature, and it has doubtless operated not a little in weakening prices, for traders looked for a return a good deal better than this. Probably it would have been if business with America had developed as was anticipated. Not since April, 1907, has there been such a stock in Connal's as was reported at November 30th—363,218 tons, an increase for the month of 27,733 tons. At the end of the first half of last year the total stock was under 48,000 tons, or about an eighth of the present quantity. On November 30th the stock of No. 3 Cleveland pig iron in Connal's was 331,833 tons, increase during month 22,823 tons; of other iron deliverable as standard, 28,625 tons, increase 5060 tons; and of iron undeliverable as standard, 2760 tons, decrease 150 tons.

Realised Prices of Manufactured Iron.

The Board of Conciliation and Arbitration for the manufactured iron trade of the North of England have been informed by their accountants that the average price realised by producers in the district for the manufactured iron delivered by them during September-October last was £6 6s. 11·55d. per ton, or 3·39d. more than in the previous two months, and wages for December-January will, according to the sliding scale arrangement, be the same as those during October-November. The lowest price of the recent depression was £6 6s. 7·16d. in May-June last, and there is thus an improvement of 4·39d. As compared with September-October, 1908, the price has fallen 5s. 4·13d. per ton, and over this year the decrease has been 6s. 6·16d., while the rate for puddling is 6d. less and other wages have fallen 5 per cent. It is satisfactory to note increased deliveries of shipbuilding materials.

Manufactured Iron and Steel.

While a lull must be reported in the business being transacted in manufactured iron and steel just now, producers are well off for orders, and generally keep their mills in fuller operation than for two years past, especially where plates and angles are produced. Prospects are encouraging, and some of the producers are, it is said, contemplating advances of quotations. Messrs. Bolckow, Vaughan and Co., Middlesbrough, have obtained the order from the Federated Malay States Railways for 6000 tons of steel rails and 500 tons of fish-plates. The quotations in this district for manufactured iron and steel are as under:—Steel and iron ship plates, £6; steel ship angles, £5 7s. 6d.; iron ship plates, £7; packing iron and steel, £5 5s.; steel bars, £6; iron bars, £7; steel sheets (singles), £7 5s.; steel hoops, £6 5s.; steel strip, £6 2s. 6d.; iron ship rivets, £7 5s., all less 2½ per cent. f.o.t. Galvanised and corrugated steel sheets, 24 gauge in bundles, are at £11 5s., less 4 per cent. f.o.b. Heavy steel rails are at £5 5s.; and cast iron chairs £3 10s., both net f.o.b. Shipments of steel last month from the Tees reached 45,324 tons, against 38,518 tons in November, 1908, and of manufactured iron 8862 tons against 8505 tons. Of this, 16,781 tons went to Africa; 14,028 tons to India; and 7378 tons to South America. The quantities to Japan and Australia were smaller than usual. The eleven months' return of manufactured iron and steel exported was 586,019 tons against 529,249 tons in 1908.

Shipbuilding and Engineering.

The improvement in the demand for new vessels continues, and builders are now in such positions that they have in many cases put up their prices. Tyne builders have this year launched 93 vessels, against 99 in 1908, and there are more of the higher classes being built there. The proportion of tramp steamers building is less than in former years. Messrs. Short Brothers, Sunderland, have secured orders for three ocean colliers, each of 7000 tons d.w., for Canada, and it is said that these will be built on the Isherwood system. There is reason to believe that the worst has been experienced in the engineering industry, and more men are employed at the various establishments, but it cannot be said that prices are satisfactory for the employers.

Coal and Coke.

The demand for coal of all kinds shows some improvement, and consumers are pressing for quick deliveries, for they apprehend some trouble in the New Year when the Miners Eight

Hours Act will have come into force in Northumberland and Durham, half a year after it took effect in all other districts. The coalowners and the men's representatives have had various conferences during the last few weeks to discuss the arrangements, but the negotiations have not resulted in anything definite being decided upon. The men have made certain claims about regulating wages, which the employers are hardly likely to agree to. The men want the future basis of wages to be, not the average selling prices, as heretofore, but the average profit realised. The coal trade is therefore in a rather unsettled state, but collieries are working to their fullest capacities, and are likely to be kept going as satisfactorily up to Christmas. Prices have risen, and best steam coals are now at 11s. f.o.b., while steam smalls are at 6s. 6d.—advances of 6d. per ton this week; best gas coals are up to 11s., and bunkers realise from 9s. 6d. to 10s., according to quality. Furnace coke is at 17s. 6d., delivered at Middlesbrough works. It is generally expected that higher prices will rule next year, partly because of the increased cost of working.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

General Condition of Business.

THE iron and metal trades generally are suffering from depression, and there is scarcely anything in the present outlook to arouse expectation of an early revival. Indications of greater ease in the money market might be accepted as a favourable point, from a speculative point of view, were it not that prospects in America and elsewhere are less encouraging than they were a few weeks ago. There is now added the disturbing influence of political agitation, so that the outlook is somewhat clouded at the moment.

The Pig Iron Market.

There has been comparatively little business in pig iron warrants in the last few days. The demand has greatly fallen away both as regards cash and future iron, and there has been a sharp reaction in prices of Cleveland iron. Business since last report has been noted at 50s. 10d. to 49s. 10½d. cash, 51s. 3½d. to 50s. 2½d. one month, and 51s. 11d. to 50s. 11d. three months. Transactions have also occurred at 50s. 9d. for delivery in eleven days, and from 50s. 10d. to 50s. fourteen days. A considerable amount of iron is understood to be carried for delivery before the end of the year. Statistics of business and of shipments are not encouraging. The very most has been made on 'Change of reported inquiries from America and Germany, but so far these have not given much cause for hope as to an early improvement in business.

Scotch Makers' Iron.

There has been a quiet market for Scotch makers' pig iron, but the values of special brands are well maintained. Free at ship in Glasgow harbour, Monkland and Govan, Nos. 1, are quoted 57s.; No. 3, 55s.; Carnbroe, No. 1, 60s. 6d.; No. 3, 57s. 6d.; Clyde, No. 1, 62s.; No. 3, 57s.; Gartsherrie and Calder, Nos. 1, 62s. 6d.; Nos. 3, 57s. 6d.; Summerlee, No. 1, 63s. 6d.; No. 3, 58s 6d.; Langloan, No. 1, 64s.; No. 3, 59s.; Coltness, No. 1, 89s.; No. 3, 59s.; Eglinton, at Ardrossan or Troon, No. 1, 58s.; No. 3, 56s.; Glengarnock, at Ardrossan, No. 1, 65s.; No. 3, 60s.; Dalmellington, at Ayr, No. 1, 62s.; No. 3, 57s.; Shotts, at Leith, No. 1, 62s. 6d. No. 3, 57s 6d.; Carron, at Grangemouth, No. 1, 64s. 6d.; No. 3, 58s. 6d. per ton. The demand for shipping iron has been moderate, and there is no improvement in the wants of home consumers. An additional furnace has been put on the production of hematite pig iron at Coltness ironworks, and there are now 44 making hematite, 35 ordinary, and 5 basic iron, the total of 84 furnaces thus in operation in Scotland comparing with 83 last week and 77 at this time last year.

The Hematite Trade.

There has been practically nothing doing in hematite warrants. Cumberland hematite is quoted 60s. 3d., which is 3d. below the price at which cash business was recently done. Merchants quote Scotch hematite 63s. for delivery at the West of Scotland steelworks. Fair deliveries are being made under existing contracts, but the current fresh business is reported to be comparatively small. Heavy arrivals of hematite ore—19 steamboat cargoes—reached the Clyde in the course of the last six days. Complaints are made that the harbour and railway authorities are not affording adequate facilities for prompt discharge and conveyance of the ore to the ironworks; but some of the congestion is due to the arrivals of vessels that were detained nearly a week down the firth by fog. The imports of ore for the past eleven months amount to about 1,000,000 tons, being 100,000 tons more than in the corresponding period of last year.

The Clyde Shipbuilding Trade.

During the past month 36,377 tons of new shipping were placed in the Clyde, compared with 42,557 in November, 1908, and 31,791 tons in November, 1907. The output of the eleven months reaches 353,905 tons, against 315,203 in the same period of last year, and 523,614 in the corresponding eleven months of 1907. A fair amount of new work has been received in the course of the month, which will considerably more than make up for the tonnage that left the stocks.

Finished Iron and Steel.

There is no improvement in the malleable iron and steel departments. Iron furnaces and mills are very indifferently employed, and prices obtainable are quite unsatisfactory, especially for export business. The steel trade is also depressed, with only partial employment. There is a good demand for thin sheets and some kinds of light material, but the heavier kinds of goods are in comparatively poor request. Founders in some cases report a good business in heavy castings for shipbuilding purposes, but there is a lack of business in other directions.

The Coal Trade.

The coalmasters have raised the price of coal beginning on 1st instant another 1s. per ton, this being the second advance within a few weeks. For manufacturing purposes the demand has only been moderate, and consumers have been complaining about the advance at a time when they are not merely unable to obtain a corresponding rise in their prices, but when their works are actually partly idle. House and splint cones have met with a ready sale, and there has also been a little more done in navigation coal. At Glasgow Harbour the f.o.b. prices now are for ell and steam coals 9s. 9d. to 10s., and splint 10s. 6d. to 11s. per ton.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Last Week's Coal Trade.

IT was currently reported on 'Change that several important Admiralty orders had been booked. What the quantities were, or the dates fixed, or even the prices obtained, are kept secret, though, as in former cases, they will ooze out in a little time. The influence of these prices on the market is marked, and that is one reason why they are kept secret; and then, again, buyers are not willing that these transactions should become public property. Upon one head the public may be satisfied, that the leading coalowners are content, and the tone of business has been somewhat improved. The standing grievance in the trade has been the losses incurred by the working of the Eight Hours Act. In all quarters I hear a strong expression of regret that Parliament should have been induced to pass such a measure, which colliers dislike in equal ratio with coalowners.

The French State Railways.

There has been some difficulty in obtaining particulars of these, but the following are given on trustworthy authority:—Pyman, Watson and Co., 100,000 tons small and 32,400 tons large; Moxey, Savon and Co., 50,000 tons small and 75,000 tons large; E. William Cook, 30 000 tons small; Société Commerciale, 3),000 tons small; C. L. Clay and Co., 20,000 tons small; Cory's Trading Co., 18,000 small and 7000 large; Budd and Co., 8840 small; Glanme Pereire, 6000 small; Guerer, Honfleur, 1670 small. This makes a total of 345,000 small and 114,400 tons large. Prices obtained are stated to be equivalent to 7s. 10d. f.o.b. for the small, 14 per cent. ash guaranteed, and 13s. 9d. f.o.b. large; all coal to be second-class Monmouthshire.

Other Large Contracts for Welsh Coal.

On 'Change, Cardiff, this week it was stated that the Orient Steamship Company has contracted for about 150,000 tons of Insole's large steam coal at about 15s. 6d. per ton f.o.b. The Shire Line are stated to have placed contracts for 80,000 large steam at from 15s. 6d. to 15s. 9d. f.o.b.; and a good second-class Admiralty coal, to the extent of 75,000 tons, at about the same figure, is said to have been booked by another firm. So far the Australian strike has not been productive of much business to the Welsh coal trade. A cargo of 7000 tons is reported to be preparing, and other cargoes booked for Eastern ports, with option for Australia, are likely to follow.

Latest Prices at Cardiff.

Best large steam, 16s. 3d. to 16s. 6d.; seconds, 15s. 6d. to 16s.; ordinaries, 14s. 6d. to 15s.; best drys, 15s. 9d. to 16s. 3d.; ordinary drys, 14s. to 14s. 6d.; best washed nuts, 14s. to 14s. 6d.; seconds, 13s. to 13s. 6d.; best washed peas, 12s. to 13s.; seconds, 10s. to 11s. 6d.; very best smalls, 8s. 6d. to 9s.; best ordinaries, 7s. 9d. to 8s. 3d.; cargo smalls, 6s. 9d. to 7s. 3d.; inferior kinds, 6s. to 6s. 9d.; very best Monmouthshire black vein, 15s. 3d. to 15s. 6d.; ordinary Western Valleys, 14s. 6d. to 14s. 9d.; best Eastern Valleys, 13s. 9d. to 14s.; seconds, 13s. to 13s. 3d. Bituminous coal: Very best households, 17s. to 18s.; best ordinaries, 15s. to 16s.; No. 3 Rhondda, 17s. 3d. to 17s. 6d.; brush, 13s. 6d. to 13s. 9d.; smalls, 10s. to 10s. 6d.; No. 2 Rhondda, 12s. 9d. to 13s.; through, 9s. 6d. to 10s.; smalls, 7s. to 7s. 6d. Patent fuel, 15s. to 15s. 6d. Coke: Special foundry, 24s. to 27s. 6d.; foundry, 19s. to 20s.; furnace, 17s. to 17s. 6d.; pitwood, 19s. to 19s. 6d.

Newport Coal.

Steadiness was a feature of the market this week; best coals are in demand, also good seconds. The weather continues to be a deterent. December bookings have been fairly good. Latest:—Very best black vein large, 15s. to 15s. 3d.; Western Valleys, 14s. 3d. to 14s. 6d.; Eastern Valleys, 13s. 6d. to 13s. 9d.; other kinds, 12s. 6d. to 13s. 3d.; best smalls, 7s. to 7s. 6d.; seconds, 6s. 3d. to 6s. 9d.; inferiors, 5s. 9d. to 6s. 3d. Bituminous coal: Best house coal, 15s. to 15s. 6d.; seconds, 14s. to 14s. 6d. Patent fuel, 15s. to 15s. 3d. Coke: Foundry, 18s. to 19s.; furnace, 17s. to 17s. 6d. Pitwood, ex ship, 19s. 3d. to 19s. 9d.

Swansea Coal.

Latest reports are that a fair demand exists, with a steady undertone. Some of the special qualities were noted as follows:—Swansea Valley in better demand, firm; Red vein, no alteration; machine-made coals, no change, firm; German nuts excepted; rather weak. Latest:—Best malting, hand-picked, 23s. to 24s. net; second malting, 21s. to 22s. net; big vein, large, 17s. 6d. to 19s., less 2½; red vein, 12s. to 13s., less 2½; machine-made cobbles, 23s. to 24s. net; Paris nuts, 26s. to 27s. net; French nuts, 26s. to 26s. 6d. net; German nuts, 25s. to 26s. net; beans, 18s. 6d. to 19s.; machine-made large peas, 11s. to 12s. 6d. net; fine peas, 10s. 6d. to 11s. net; rubbly culm, 5s. 6d. to 5s. 9d., less 2½; duff, 2s. 6d. to 3s. net. Steam coal: Best large, 17s. to 18s.; seconds, 14s. 6d. to 15s.; bunkers, 9s. 6d. to 10s. 6d.; small, 7s. to 9s., less 2½. Bituminous coal: No. 3 Rhondda, 18s. to 18s. 6d.; through, 14s. 9d. to 15s. 6d.; small, 10s. 3d. to 10s. 6d., all less 2½ per cent. Patent fuel, 13s. to 13s. 6d., less 2½.

Iron and Steel.

The ironmaking community of Wales were busily engaged this week in discussing the fact that the Transvaal requirements for steel rails had been sent to Russia. The official reason given was that all the manufacturers of steel rails in the kingdom were members of a "ring," and the prices of the ring were from £5 5s. to £5 7s. 6d. per ton f.o.b., which meant £6 2s. 6d. to £6 5s. per ton in Delagoa Bay, as against £5 13s. and £5 14s. quoted by Russian ironworks. The only ironworks not in the ring were asked to give a quotation, and this was the Steel Corporation in Canada, who quoted £5 18s. per ton in East Durban and Delagoa Bay. The sea freight, which accounts for the difference, is 17s. 6d. per ton. It is stated that the saving effected has been £20,000. There is no general improvement in trade. The new plant at Dowlais is turning out satisfactory. A few cargoes have come to hand, pig iron from Grimsby, one of 990 tons to Messrs. Thomas, Newport. Little import of iron ore, but one to Guest and Co. Latest prices at Swansea:—Pig iron: Welsh hematite, 60s. 3d. cash and month; Middlesbrough, 49s. 11d. cash and 50s. 3d. month; Scotch, 56s. cash and month; Welsh hematite, 66s. to 67s. 6d., delivered; East Coast hematite, 64s. to 65s. c.i.f. Steel bars: Siemens, £4 15s. to £4 16s.; Bessemer, £4 12s. 6d. to £4 15s. Bilbao ore, at Cardiff and Newport, 16s 6d. to 17s., on basis of 50 per cent. iron. Other quotations: Block tin, £141 10s. cash and £143 7s. 6d. three months; copper, £158 2s. 6d. cash, £159 2s. 6d. three months. Lead: English, £13 11s. 3d.; Spanish, £13 1s. 3d. Spelter, £23 2s. 6d. Silver, 23½d. per oz.

Tin-plate.

In the Llanelly district there has been a little less activity than was desirable, and inquiries have quieted down; but there is a confident impression that the slackness is only temporary, and good times are yet ahead. The new mills have been started, and all passed off in the most encouraging manner. The extensions are expected to give employment to 300 extra men. In the Swansea district everything continues in a most flourishing state. The mills throughout the Valley are being worked with energy, all of them giving full time daily. This may be clearly accepted, the quantity brought from works during the week almost touching 80,000 boxes. Shipments were limited to 61,724 boxes, and stocks now remaining are increased to 76,729 boxes. At Swansea the demand for tin-plate is well sustained, and prices are firm. Ordinary plate, Bessemer and Siemens, 12s. 4½d. to 12s. 6d.; ternes, 22s.; C.A. roofing sheets, £8 10s. to £8 15s.; big sheets for galvanising, £8 10s.; finished black plates, £9 10s. to £9 15s.; galvanised sheets, 24 g., £11 per ton.

AMERICAN NOTES

(From our own Correspondent.)

NEW YORK, November 24th.

THE scarcity of raw steel material has become so pronounced that importations from Germany are being made, most of them for delivery along the Atlantic coast. Several 1000-ton lots have been taken by eastern mills whose demands upon western mills could not be met. The price delivered 29.25 dols. Western Pennsylvania consumers are now figuring upon importing billets, not so much on price, which ranges from 27 dols. to 28 dols. per ton, but because there is a prospect that they may not be able to obtain them at any price. Sheet bars are also very scarce, and even at 30 dols. orders cannot be placed for delivery during the first quarter of next year. Sheet and tin plates are very active at the advance made ten days ago. The shortage of cars in the coke region is pronounced, and shippers are waiting for 600 cars to come to their rescue. The six large steel car plants controlled by the Pressed Steel Car Company have orders for 160,000 steel cars, against 60,000 same time last year, and by running night and day until next June they will be able to fill the orders now on hand. There is not enough steel wheel capacity in the country to supply wheels for all of these cars, and hence the activity of the Carnegie Steel Company in building a new car-wheel plant, which, it is expected, will be turning out wheels by February 1st.

The plate mills are oversold and some Pittsburg mills were obliged to refuse orders for large quantities from steel car builders, because they could not deliver the steel within four months. They are sold up until the middle of April. The owners of the salmon fisheries on the Pacific Coast have contracted for so much sheet that the mills will find it difficult to fill any more orders before February. The mills making merchant pipe and iron pipe are well over sold, and still more business is coming along. The demand for steel bars has taxed the capacity of the mills, and recent anxious buyers have voluntarily offered premiums without securing the expected accommodation. Four of the larger producers are vigorously expanding their productive capacity. Several manufacturers of wire products have recently refused to book orders for delivery after December 15th. There is a probability of an advance between now and then. Those familiar with the inside of the industry know that there is a great deal of business lurking around for every steel product known, and they know that this demand will have a disturbing effect sooner or later on the present range of prices. The most important legal decision has just been given out by the United States Circuit Court at St. Louis declaring the Standard Oil Company an illegal corporation. The case will, of course, be appealed to the United States Supreme Court. The exports of copper for the first eighteen days of November amount to 15,000 tons, the shipments of the past week being 6800. Electrolytic is strong at 13½.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

WE are asked to state that Mr. Conrad F. Mendham, M.I. Mech. E., has removed his offices from 14, Fenchurch-street, to 85, Gracechurch-street, where he is continuing his practice as consulting and inspecting engineer. Telegraphic address: "Pyrotic, London." Telephone: 9471 Central.

MR. M. J. STEPHAN, Ph.D., M.I.M.M., has taken Mr. M. C. Carr-Gomm, Assoc. M. Inst. C.E., A.M.I. Mech. E., into partnership, and they are now carrying on business as consulting mining and mechanical engineers and petroleum experts at No. 6, Broad-street-place, E.C., under the style of "Stephan and Carr-Gomm."

GREAT EASTERN RAILWAY LOCOMOTIVE DEPARTMENT STAFF DINNER.—The sixth annual re-union dinner of past and present members of the locomotive department staff of the Great Eastern Railway was held in the Norfolk Room of the Great Eastern Hotel, Liverpool-street Station, on the 26th November, when Mr. S. D. Holden, the present locomotive superintendent, presided over a gathering which numbered fifty-four, some of whom had been drawn from places so far remote as Birmingham, Manchester, Faversham, Ipswich, Brandon, Norwich, Newton-le-Willows, and Hexham, whilst, in addition, the company included a Stratford man, who is at present on leave in this country from India. The evening was a great success. On the proposal of Mr. A. P. Parker, seconded by Mr. T. W. Ford, the present committee, consisting of Messrs. James Holden (chairman), W. F. Pettigrew, J. W. Howard, Godfrey Elliot, A. J. Hill, F. V. Russell, and A. W. Polley (Hon. Sec.), was re-elected with the addition of Messrs. S. D. Holden and D. Gilliee. On the proposition of Mr. Collingwood, a vote of thanks to the committee was passed. In responding, Mr. A. W. Polley said it was the desire of the committee to make the dinner as representative as possible, and that if any members would forward the names and addresses of any other old Stratfordians the committee would be glad to receive them.

CONTRACTS.—The Standard Engineering Company, Limited, of 63, Queen Victoria-street, E.C., has secured the order in connection with the heating and ventilation of the new motor cab garage now being built by Messrs. Panhard and Levassor at Acton Vale. It has been decided to adopt the firm's "Stanlock multiple unit system." The building in question is approximately 600ft. long by 300ft. wide, and the scheme embraces not only the heating and ventilation of the garage itself but also the office building, stores, and chauffeurs' mess-room, &c. &c.—We understand that Cryselco Limited, of Kempston Works, Bedford, manufacturers of "Cryselco" carbon and metal filament lamps, has received the contract for the supply of lamps to the Shanghai Municipal Council for the ensuing twelve months.—Meldrum Brothers, Limited, of Timperley, have received a repeat order for three sets of their improved high-pressure Simplex mechanical stokers for a large woollen mill in the Huddersfield district, and also an order from another woollen mill to modify a stoker of another manufacturer to this system.—The choice of the type of plant to be installed for the extensions at the Sydney, N.S.W., generating station has fallen on Willans and Robinson turbines and on Dick Kerr alternators. Two units, of 4000 kilowatts each, running at 750 revolutions per minute, are to be installed.—The contract for eighteen pumps, which will be installed in connection with the waterworks extensions at Toronto, has been given to Jens Orten-Boving and Co., which firm also secured an order for four pumps, with a capacity of 16,000,000 gallons each, for the high-level pumping station.

THE DAIMLER MOTOR CAR COMPANY, LIMITED.—On the invitation of the Daimler Motor Car Company, Limited, a number of gentlemen travelled by special train from Euston to Coventry on Wednesday for the purpose of inspecting the firm's works at the latter place. On arriving at Coventry, the guests were conveyed by motor car to the works, where a pleasant morning was spent in examining the many processes involved in the manufacture of the well-known Daimler car. The shops at the present moment are fully employed, and are being largely extended to meet future requirements. Under the guidance of members of the firm and their staff, the guests were shown in a most thorough fashion over all the different shops in the works. In these the excellent arrangements made for the economical and efficient manufacture of the component parts of the cars, and for the comfort and health of the workers, were greatly admired by all who took part in the visit. The business of the firm has been almost completely reformed since the introduction of the "Silent Knight" engine, and in the organisation of every detail associated with the manufacture of that engine, and that of the various types of car for which it ultimately provides the motive power, the capable control of the firm's undertaking is readily seen. Luncheon was afterwards served when a party of about 250 partook of the company's hospitality. In the speeches which followed there was expressed a universal appreciation of the arrangements made by the company for the comfort and enjoyment of its guests. Among others, Earl Russell, Mr. A. E. W. Mason, Mr. Philip Dawson, and the Mayor of Coventry spoke on behalf of the guests, while the firm was represented among the speakers by the chairman, Mr. E. Manville, Mr. U. Stratton, and Mr. C. Y. Knight. In the afternoon the guests were conveyed in motor cars to the station where the special train was in waiting for the return journey to London.

NOTES FROM GERMANY, FRANCE, BELGIUM, &c.

(From our own Correspondent.)

Rheinland-Westphalia.

THE fact that prices, both for raw and for manufactured iron, have again met with slight advances during this week and the last speaks well for the general condition of the market. It is reported from Düsseldorf that German and Luxemburg forge pig have been raised M. 1 and M. 2 p.t., and steel bars, which were standing at M. 102 to M. 108 p.t. in the beginning of November, are quoted M. 104 to M. 108 now; steel plates M. 110 to M. 115 p.t., instead of M. 108 to M. 115 p.t., and steel plates for boiler-making purposes have been raised from M. 118 to M. 120 p.t. free at works. The Union of German Ironfounders in Hagen has resolved to raise prices M. 2 p. 100 kilos., in consequence of improving demand, and also because the prices hitherto quoted were quite unremunerative. A new contract for two years has been signed between the Steel Convention and the Prussian State Railways for the supply of rails, iron sleepers, and hardware. The basis price for rails was fixed at M. 116, for iron sleepers M. 107, and rates for hardware have likewise been reduced; on an average the present prices are M. 4 p.t. lower than two years ago, but compared with 1904 sleepers realise M. 2 p.t. more, and rails M. 4 p.t. Foreign orders in heavy rails are reported to come in regularly; also in light section rails a good business is done, both locally and on foreign account. Specifications have increased in sectional iron; inland dealers buy freely now, and the outlook is favourable in this department.

Silesian Iron Industry.

There has not been any noticeable improvement in the iron and steel trade since former letters, but all the principal establishments can be reported as in regular employment; new business is coming rather freely to hand in the manufactured iron industry. A report from Berlin says that dealers have offered bars at M. 4 to M. 5 p.t. less than producers. For immediate delivery offers at M. 99.50 p.t. free Düsseldorf are reported to have been made.

Coal.

Symptoms of improvement have been noticed in the coal trade; blast furnace coke meets with increasing demand, and is very stiff in price. Shipments to South Germany are still rather limited. The want of wagons is causing delay in the Upper Silesian district, but on the whole business moves on steadily, and there is an improving demand for house coal.

Austria-Hungary

Prices having been fixed for the immediate future there was rather more inquiry coming in, dealers purchasing freely now. In some articles, however, a falling off in demand could be felt; the machine and construction shops, for instance, are complaining of a slow and insufficient trade, and they are but indifferently occupied. In the coal trade the condition does not differ from that of previous weeks, a pretty good business being done generally.

Favourable Accounts from France.

Extensive orders that have been placed by local railways have tended to improve the position of the market in France. Negotiations are also being carried on regarding orders for the East and North Railways, orders for 600 20-ton coal wagons, and 800 trucks being about to be placed. Also the Orleans Railway intends increasing its rolling stock, and the outlook, therefore, is favourable in the railway department. The accounts given from other branches of the iron industry also show that a regular activity prevails. All descriptions of fuel meet with good request in France.

Upward Tendency in Belgium.

Favourable accounts continue to be given of the iron and steel trade, orders coming to hand freely in all departments. Considerable firmness characterises the bar trade, and plates also show more animation, especially the lighter qualities. Heavy sorts of sectional iron meet with good request on foreign account. Inland prices for girders have stiffened a little in consequence of the prolongation of the French Girder Syndicate. Foreign competition being less keen on the pig iron market, a stiffening tendency can be noticed in prices. Foundry pig No. 3 is quoted 67f. p.t., while forge pig and basic stand at 61f. and 68f. p.t. Output continues to increase. Of forty-four existing blast furnaces, thirty-seven are at present in blow, with a daily output of 5363 t.; only seven blast furnaces are out, against thirteen at this time last year. During the first ten months of this year 1,322,490 t. were produced, against 987,570 t. in the corresponding period last year, which shows an increase of 334,920 t. For October an increase of 35 per cent. is noted as compared with the same month last year. Semi-finished steel remains steady, and it is generally expected that the prices now ruling will also prevail during the first quarter of 1910. Coal and coke are well inquired for in Belgium, whereas briquettes remain dull. In the Mons and in the Borinage district the keen competition of English and French firms is complained of.

INSTITUTE OF MARINE ENGINEERS.—At the institute of Marine Engineers on Monday, November 22nd, a lecture was given by Mr. A. T. Strohmenger, F.I.C., on "Notes on Coverings for Boilers and Steam Pipes." Mr. John Lang, R.N.R., Member of Council, occupied the chair. In the course of his lecture Mr. Strohmenger said it could be safely assumed that the losses through direct radiation from conveyors carrying heat energy in the form of steam were exceedingly small. From an uncovered boiler or pipe the losses were undoubtedly primarily due to conduction and convection. The properties of a desirable covering might be summarised as follows: It should offer a high resistance to the passage of heat; it should be capable of being easily removed; its efficiency should not be impaired by variations of temperature, the action of steam or water, vibration, rough handling, or physical or chemical changes over a term of years; its specific weight should not be so high as to place an undue stress on the steam pipes; it should have no action on the metal surface lagged; it should be non-inflammable; and its specific heat should be as low as possible. A discussion followed the reading of the paper.

THE ANDREW CARNEGIE RESEARCH SCHOLARSHIP.—A Research Scholarship or Scholarships, of such value as may appear expedient to the Council of the Iron and Steel Institute from time to time, founded by Mr. Andrew Carnegie (past-president), who has presented to the Iron and Steel Institute 100,000 dols. for the purpose, will be awarded annually, irrespective of sex and nationality, on the recommendation of the Council of the Institute. Candidates, who must be under thirty-five years of age, must apply on a special form before the end of February to the Secretary of the Institute. The object of this scheme of Scholarships is not to facilitate ordinary collegiate studies, but to enable students who have passed through a college curriculum or have been trained in industrial establishments to conduct researches in the metallurgy of iron and steel and allied subjects, with the view of aiding its advance or its application to industry. There is no restriction as to the place of research which may be selected, whether university, technical school, or works, provided it be properly equipped for the prosecution of metallurgical investigations. The appointment to a scholarship is to be for one year, but the Council may at their discretion renew the scholarship for a further period instead of proceeding to a new election. The results of the research are to be communicated to the Iron and Steel Institute in the form of a paper to be submitted to the annual general meeting of members, and if the Council consider the paper to be of sufficient merit the Andrew Carnegie Gold Medal will be awarded to its author.

BRITISH PATENT SPECIFICATIONS.

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-office Sale Branch 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

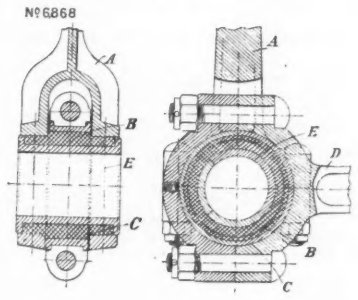
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-office of opposition to the grant of a Patent.

STEAM ENGINES.

6868. March 22nd, 1909.—IMPROVEMENTS IN OR RELATING TO BIG END CONNECTIONS, *Etablissements de Dion-Bouton (Société Anonyme)*, 20, *Quai National Puteaux, France.*

This invention relates to improvements in securing two big ends to a crank pin. This invention is particularly applicable to engines comprising two or more cylinders, each pair of cylinders having a V-setting. In this case each crank pin will carry two big ends, and it is found possible, according to this invention, to arrange them so that the axes of the two connecting-rods lie in the same plane. One of the connecting-rods A is provided with a bifurcated big end as shown. Mounted in this is a ring B of hardened steel. The ring B is provided with an enlarged portion projecting between the two arms of the big end A, upon which is mounted a

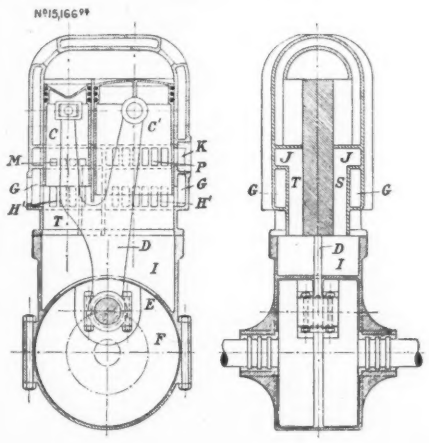


ring C carrying the big end of the second connecting-rod D. The ring C is provided with flanges or enlarged portions at each edge, which come in contact with the bifurcated arms, and so prevent lateral play between the two big ends. The ring C is lined with two brasses E which form the contact surface working on a crank pin. In constructing the various parts, the brasses E and the ring C are formed in two halves, and the big ends are formed in the usual manner. It is obvious, therefore, that when the two portions of the big end A are clamped together, the brasses E and the ring C, although both are constructed in two portions, will form substantially complete and rigid members. The bearing surface of the connecting-rod D is not large, but this is of no importance, as the two parts in question merely oscillate relatively to each other.—*November 10th*, 1909.

INTERNAL-COMBUSTION ENGINES.

15,166. January 16th, 1909.—IMPROVEMENTS IN AND RELATING TO INTERNAL-COMBUSTION ENGINES, John Badger, of "Langdale," Kimberworth-road, Rotherham, York, and John William Whitaker, of 27, Abinger-road, Chiswick.

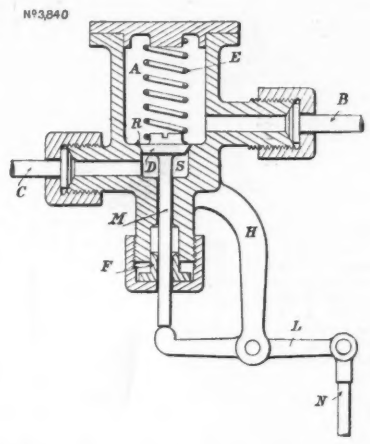
According to this invention, two vertical and differential cylinders are employed in a plane at right angles to the axis of the crank shaft, and having their axes parallel and set over on either side of the said crank shaft. The cylinders are fitted with pistons C C¹ which perform the combined function of transmitting power to the crank shaft due to the explosion of the combustible



gases and also act as valves for the inlet and exhaust of the gases. The pistons are connected to the crank shaft by a forked connecting-rod D working on the crank pin E. The crank shaft is contained in an enclosed chamber F upon which are mounted the cylinders. An annular collecting chamber G for the explosive mixture is provided, from which leads a serrated passage or port H¹ to the suction and compression chamber I. From the suction and compression chamber I two passages or ports S T lead into a distributing chamber J from which a serrated passage or port M leads into the cylinder on the left. From the cylinder on the right a serrated passage or port P leads into the exhaust chamber K. To ensure a gas-tight crank chamber F, the crank shaft has provided a series of collars as shown.—*November 10th*, 1909.

3840. February 16th, 1909.—IMPROVEMENTS IN LUBRICATING SYSTEMS FOR INTERNAL COMBUSTION ENGINES, Frederick Henry Royce, of Nightingale-road, Osmaston-road, Derby.

Two automatic supplies are employed, the one (hereinafter called the constant supply) adapted to give a predetermined amount of oil which is sufficient efficiently to lubricate the engine at low powers without smoking, and which is always in action, and the other (hereinafter called the auxiliary supply) adapted to give a predetermined amount of oil which is sufficient, with the constant supply, efficiently to lubricate the engine at high speeds or increased loads; also automatically controls said auxiliary supply by any suitable means so that the quantity of oil supplied varies with the load on the engine. The constant supply may be either on the splash, drip, or forced-feed system. One method for controlling the auxiliary supply is shown in the drawing, where A is a chamber into which the auxiliary supply of oil is led by means of the pipe B. In the chamber A is a diaphragm R, which forms a second chamber S, from which a pipe C is led, which is connected to the pipes leading to the various cylinders. In the diaphragm is a hole, which is closed by a valve D, which is pressed down on its

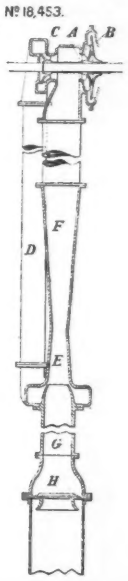


seating by a spring E, and the stem M of which passes through a stuffing-box F in the bottom of the chamber A. On to a bracket H is pivoted a lever *l*, one end of which is connected by the rod N with the mechanism controlling the throttle valve and the other end of which is adapted to contact the free end of the stem M of the valve D, such a clearance being provided between the end of the stem and the end of the lever as will prevent the valve being opened until the throttle valve has been opened a predetermined amount, and will correspondingly allow the valve D to shut prior to the throttle valve closing.—*November 10th*, 1909.

PUMPING AND BLOWING MACHINERY.

18,453. August 10th, 1909.—PROCESS AND MEANS FOR INCREASING THE HEIGHT OF SUCTION LIFT IN PUMPS, *La Société d'Exploitation des Appareils Rateau, of 20, rue d'Anjou, Paris, France.*

In front of the inlet A of the centrifugal wheel B (or of a set of wheels) is disposed a helicoidal wheel C, the discharge passage D of which terminates in an ejector E which is placed in the required position on the suction pipe F G, the latter being as usual provided with a non-return foot valve H. The device works in the following manner:—The pipe F G and the pump B are first filled with water and rotary motion is imparted to the helicoidal wheel C. The non-return foot valve H immediately opens, even if the height of the suction column exceeds 10 m. The helicoidal wheel C takes a portion of the liquid before its



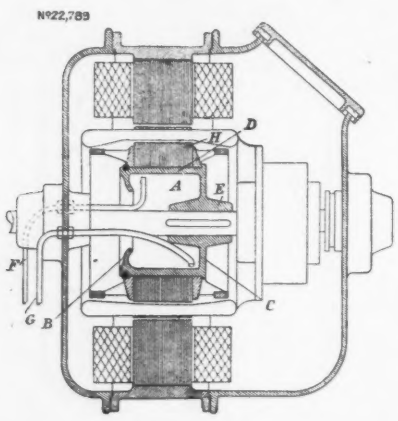
entry into the inlet of the pump B and forces it into the conduit D. This by-passed portion of the liquid enters the annular space of the ejector E, whilst the liquid coming from the lower part G of the suction pipe passes through the internal nozzle of the ejector. The liquid coming from D carries along with it the sucked-up fluid and in such a manner that the pressure of the sucked-up liquid becomes increased in the portion F of the conduit forming the outlet of the ejector. If, for instance, the conduit D has a section equal to that of the conduit G whilst the section at F is twice as great, in imparting to the liquid in D a pressure represented by H it has been found that the ejector raises the pressure of the sucked-up liquid by about $\frac{H}{3}$. In the case more particularly of water, if the total height of the column F G be 10 m, everything will go on as if this height were reduced at 10— $\frac{H}{3}$, and it is thus possible to draw from an even greater depth than 10 m. Modified arrangements are dealt with.—*November 10th*, 1909.

DYNAMOS AND MOTORS.

22,789. October 6th, 1909.—IMPROVEMENTS IN COOLING DYNAMO-ELECTRIC MACHINES, Siemens Brothers' Dynamo Works, Limited, of Caxton House, Tothill-street, Westminster.

The dynamo armature is denoted by A, that part of the armature hub which is keyed to the shaft by E, and the circumference of the hub by D. Baffle plates or edges are denoted by B and C, the latter serving also to connect D and E mechanically together. A tube F conducts liquid to the armature, and the return tube is shown at G. The end or nozzle of the latter is bent

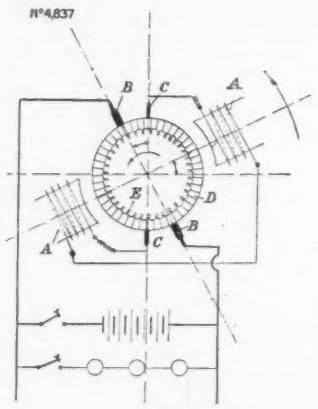
so that its orifice points in a circumferential direction which is opposite to the direction of rotation of the armature, in order to facilitate the carrying away of the heated fluid. The nozzle of F is preferably arranged so that it points in a circumferential direction which agrees with the direction of rotation of the armature, and the liquid is thus thrown on to the inner circumference of D at a speed which agrees more or less with the peripheral speed of D itself, splashing being thereby avoided. The inner circumference of D is preferably made in the shape of



a cone, having its greatest diameter at that end which accommodates the return tube G. This has the effect of causing the circulating fluid to gradually work its way in a spiral path from F to G, and tends towards economy in the amount of liquid used. The armature core plates are preferably placed in as close contact as possible with D. An automatic arrangement cuts off the supply of liquid as soon as the armature ceases to revolve or as soon as the speed is reduced below a predetermined limit. —*November* 10*th*, 1909.

4837. February 27th, 1909.—Improvements relating to Electric Generators Giving Constant Pressure under Varying Speeds, *Georges Dedain, of* 32, *rue Rennequin, Paris, France.*

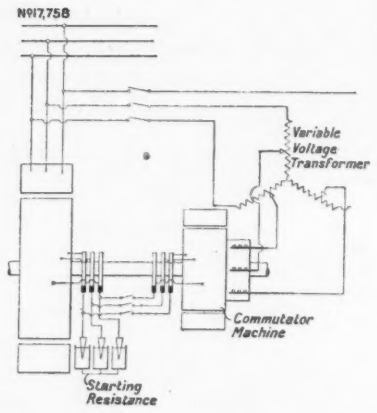
This invention relates to electric generators giving constant maximum pressure under varying speeds of the armature or rotor, and is designed more especially for use in lighting automobiles, railway trains, and generally in all cases where constant pressure is required under varying speeds. The field magnets A A of a bi-polar dynamo are excited through the intervention of two stationary brushes C C receiving the current from the commutator D of the machine. The two movable brushes B B are connected with the main circuit and may be placed on the same commutator as the brushes C C, or on a second commutator of the same armature or rotor E, the poles A A being movable, and in some



nstances directly connected with the brushes B. When the maximum pressure is exceeded, the electro-magnetic reaction displaces the magnet poles in the direction of the rotation of the armature, and so dislodges the neutral line from the stationary brushes C C. Thus, the excitation furnished through the brushes C C decreases until the pressure of the current in the brushes B B becomes normal. In order to ensure the balance for any degree of excitation under each different speed it is necessary to cause the resisting couple steadying the pole pieces to decrease according to the same law as the value of the exciting flux, which latter is proportional to the difference of potential between the brushes C C, providing the magnetic circuit of the dynamo has not attained saturation. This difference of potential decreases sensibly according to a sinusoidal curve in proportion as the poles are displaced through an angle increasing from 0 to 90 degrees. Therefore, the mechanical equilibrium of the pole-pieces will be ensured with any couple with sinusoidal decrease. This resisting couple may be constituted in different manners, viz. :—By the body weight of the pole-pieces; by a weight fixed to the same; by a spring forming a decreasing couple; that is to say, by a tension spring tending to prevent the poles A A from turning in the direction of rotation of the rotor E.—*November* 10*th*, 1909.

17,758. July 30th, 1909.—Improvements in and relating to the Control of Polyphase Motors and the like, *The Allgemeine Elektricitäts Gesellschaft, of Friedrich Karl, Ufer* 2 4, *Berlin.*

This invention relates to the control of polyphase machines of the commutator type, and has for its object an improved method of speed regulation, whereby the speed may be efficiently controlled over a range varying between plus and minus 20 or 30 per cent. of the synchronous speed. In the case of large induction motors the speed regulation may be obtained by starting the motor as an asynchronous machine and regulating at low speeds by means of rotor resistances, for instance, and at speeds in the neighbourhood of synchronism, modifying the connections of the motor so that it runs as a commutator machine. With such an arrangement the commutator brushes must be raised at starting, otherwise the potential which appears at the commutator brushes would be high enough to cause destructive sparking. According to the present invention the raising of the brushes on the occurrence of destructive sparking is avoided by coupling an asynchronous machine with a commutator machine, the stator of which is unwound or is fed with currents of the same periodicity as the supply, the armature of such commutator machine being fed with currents of the same frequency as the supply and constructed as an asynchronous machine and connected with the first-mentioned asynchronous machine in cascade connection, whereby the speed in the neighbourhood of syn-

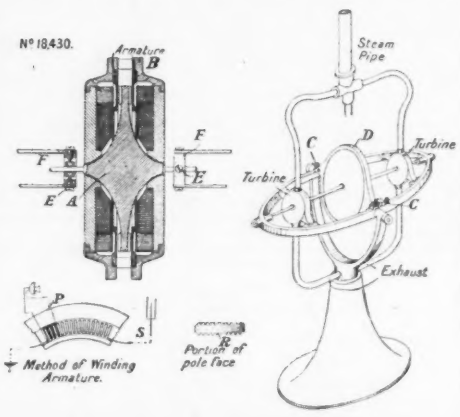


chronism may be regulated by the commutator machine which at starting and at low speeds is without current.—*November* 10*th*, 1909.

TELEGRAPHS AND TELEPHONES.

18,430. September 2nd, 1908.—Improvements in Apparatus for Producing High-frequency Electric Oscillations, more particularly applicable to Wireless Signalling, *Reginald Aubrey Fessenden, of Brant Rock, Massachusetts, U.S.A.*

There is provided the rotating disc A, shown in section, mounted upon a shaft, and preferably driven by some high-speed motor, such as a De Laval steam turbine of the type illustrated on the right. The disc A is preferably turned from a single piece of metal, and preferably made of nickel vanadium steel. The casing B should have supports adjustable in all directions by means of screws C, so that the disc may be accurately centred when in motion in order to centre the field of the generator. The centering may also be accomplished by means of a bearing ring D,

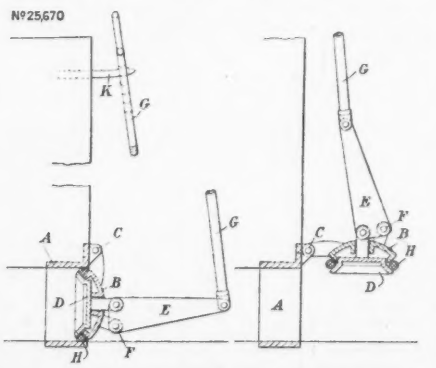


adjustable in position by means of screws E in the supporting ring F, supported on springs. The disc in rapid rotation of course tends to assume its own gravity centre. The sides or edge of the periphery of the disc is preferably slotted as indicated, and the slots R may be filled up with some non-magnetic substance, in order to present a smooth continuous surface and reduce the air friction. Otherwise, the whole machine may be mounted in a vacuum. The armature winding is indicated as formed by the conductor S. Another armature winding is also shown formed by the conductor P, which has a telephone transmitter in series with it. By putting this transmitter into action the currents in the winding P affect the strength of the currents in winding S, and if the winding S be connected to the ground and to an antenna, in the usual manner, electrical signals may thus be produced. There are two other illustrations.—*November* 10*th*, 1909.

MISCELLANEOUS.

25,670. November 28th, 1908.—An Improved Valve, Arthur John Martin, of 7, Victoria-street, Westminster, S.W.

This invention relates to an improved valve or sluice for use with water, sewage, or other liquids, constructed without any grooves or depressions in the wall of the conduit in which it is placed. A is the body of the valve, B the first plate or disc, which is hinged to the body at C, D is the second plate or disc,



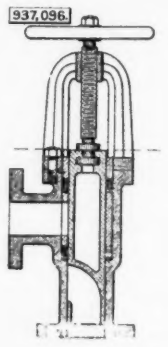
which can be moved towards or from the first by means of a lever E, hinged to plate B at F, and actuated by rod G; H is an elastic ring which is compressed between the edges of the two plates against the inner surface of the body A. The lever may be held in position by any suitable means, such, for instance, as a pin K engaging in a hole in rod G. The lever or the rod may be weighted to assist the closing of the valve, or a screw or toggle joint, or any other suitable device, may be employed for the purpose.—*November* 10*th*, 1909.

SELECTED AMERICAN PATENTS

(From the United States Patent-office Official Gazette.)

937,096. Blow-off Valve, *J. V. Schmid, Philadelphia, Pa., assignor to the Simplex Engineering Company, Philadelphia, Pa., a Corporation of Pennsylvania.—Filed May* 29*th*, 1908.

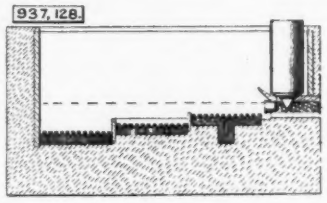
The drawing explains the nature of this invention. A plunger



with longitudinal motion takes the place of a rotating plug. There are five claims.

937,128. Method of Oxidising Metals Dissolved in Mercury, *J. Whiting, Boston, Mass., and C. F. Burgess, Madison, Wis., assignors to the Whiting Company, Boston, Mass., a Corporation of Maine.—Filed December* 16*th*, 1908.

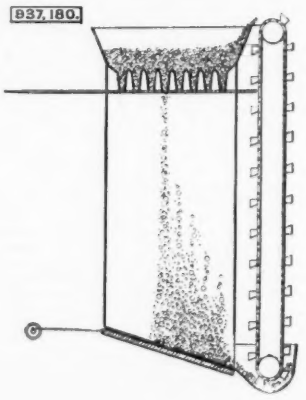
The patent is for a method of oxidising alkali metals dissolved in mercury, which consists in providing carbon surfaces exposed to an oxidising electrolyte and a moving body of amalgam, and



establishing electrical contact between th carbon and the amalgam by means of a metallic connection in contact with the carbon, and a relatively quiescent body of comparatively pure mercury underlying the amalgam. There are four claims.

937,180. Method of Finishing Metallic Surfaces, *A. Rold, Newport, Ky.—Filed December* 15*th*, 1908.

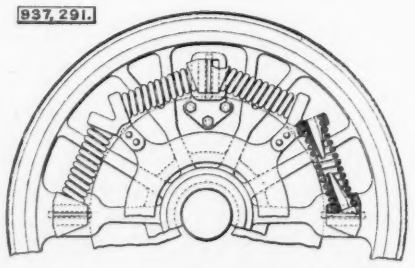
This is a very curious invention for planishing sheet metal, which consists in subjecting the surface being treated to the



impact of highly polished hardened steel balls falling from a height. The balls are raised again by a bucket ladder. There are no fewer than thirty claims.

937,291. Resilient Driving Connection *G. M. Eaton, Wilkinsburg, Pa., assignor to Westinghouse Electric and Manufacturing Company, a Corporation of Pennsylvania.—Filed January* 11*th*, 1909.

Something has been heard lately concerning a new scheme for driving turbine actuated propellers by reducing toothed gear, so that the turbine will make more revolutions than the propeller. A part of the gearing is the floating ring, which provides a flexible connec-



tion for the gear. This forms the subject of the patent. There are five claims; the third runs thus:—A resilient driving connection comprising a driving wheel, a sleeve or quill concentric with the axis of the wheel having radial projections extending between the wheel spokes, a floating ring and helical springs tangentially interposed between the ring and the projections and between the ring and the wheel spokes.

FISHGUARD HARBOUR.

No. II.*

The ocean quay.—Since the opening of the harbour in 1906, there has been constructed near the inner end of the breakwater an ocean quay, alongside which there is a minimum depth of water of 30ft. at L.W.O.S.T. The position of the quay is shown in the plan—Fig. 2, page 570—and a larger plan is given in Fig. 5, and a cross section in Fig. 6. The main structure is 274ft. in length, and varies in width from 69ft. to 79ft. At either end are narrow extensions, bringing the total length up to 400ft. The quay is constructed of Jarrah timber throughout, and the deck level is 13ft. above high water. On the deck of the structure a Customs room and a long roof covering have been erected, while the rail tracks are placed immediately behind the latter on the deck of the breakwater. One 3-ton and one 30-cwt. electric travelling cranes have been installed. Beneath the upper deck is a cattle landing. A similar wharf is to be constructed further seaward on the harbour face of the breakwater, when a depth of 43ft. will be available at low water. This quay, when completed, will be used for the direct landing of passengers and mails from Atlantic liners. At present the tenders carrying mails and passengers from the liners come alongside the inner ocean quay which we have just described. In all probability, if the increase of traffic warrants the expenditure, a continuous line of deep-water quay will ultimately be constructed along the inner face of the breakwater for a distance of upwards of 1000ft. The recently completed section of the ocean quay can be seen in course of construction in one of the engravings in the Supplement.

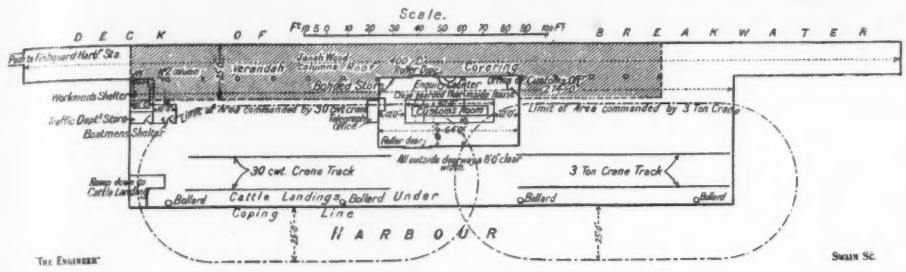


Fig. 5—PLAN OF OCEAN QUAY

The quay wall and reclamation.—The quay wall, which forms the western side of the harbour, was 1120ft. in length as originally built. The extension of this quay, which is now in course of construction, we shall refer to later. The completed quay, which is used principally for the Irish boat service, is of concrete construction, and lies, roughly, parallel with the present toe-line of the cliff, the space enclosed between the cliff and the quay wall having an average depth of about 260ft. As we have described above, about one-half of this area is reclamation, the quay wall having been constructed on the sea bed in front of the original cliff toe. The space behind the wall has been filled in with the smaller rock *débris* from the cliff blasting. A cross-section of the wall will be seen in Fig. 7; and other details are also given in Figs. 8 and 9. Photographs of the wall are reproduced in the Supplement, one of which shows a portion of the cattle gallery viewed from the harbour.

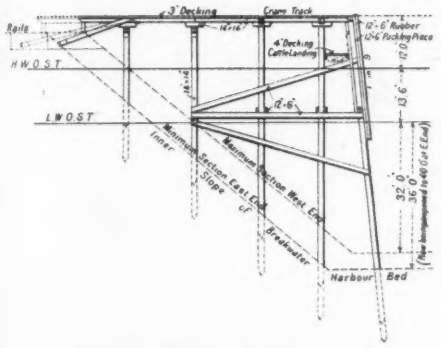


Fig. 6—CROSS SECTION OF OCEAN QUAY

The foundation of the wall is on rock, which, before the work of construction was commenced, was overlain to a depth varying from 10ft. to 12ft. by gravel and sand. A trench was first excavated by a suction dredger removing the sand; a Priestman grab and hopper barge followed and excavated the shingle down to the rock. The rock was then levelled off by divers, and any hollows filled up with concrete in bags, so that a perfectly level foundation was obtained upon which the blocks were lowered by a 15-ton Titan crane, having a 60ft. radius, which travelled upon the rock filling in rear, and later on the completed portions of the quay wall. The concrete blocks, which are gauged 6 to 1, with stone plums in addition, vary in weight from 6 tons to 10 tons, and a total of 5000 have been used in the construction of the wall. The block work is carried up to within 3ft. of high water. Above this level the work is continued in mass concrete, in which the cattle gallery—shown in the general cross-section, Fig. 7, and in the detail cross-section and elevation, Fig. 8—is formed. The wall has an average total height of 50ft., the coping level being 13ft. 3in. over H.W.O.S.T., and the base width 19ft. 6in. The average depth of water at L.W.O.S.T. along the site of the wall before construction was about 11ft., but the harbour bed has been dredged to give a minimum depth of 20ft. all over the area in front of the quay.

The cattle gallery is formed by an overhanging semi-arch, the concrete being reinforced by old 70 lb. per yard bridge rails bent to suitable shapes, as shown in Figs. 7 and 8. The footway of the gallery, which is at a level just above H.W.O.S.T., is finished with deep grooves to give a good foothold. On the seaward side the gallery is protected by a continuous line of double gates hung on creosoted memel timber stanchions placed midway between the Jarrah and Karri timber vertical fenders, which are spaced 13ft. 6in. apart centres. Any one of the gates opposite the gangway between the ship and the quay can be opened and shut back across the gallery, so as to turn the cattle in the required direction. The details of the fenders, bollards, and gates are clearly shown in the figures, and need not be further described. A subway connects the cattle gallery with the pens at the back of the passenger station, thus enabling cattle to be discharged and loaded into trucks out of sight of the passengers. There is ample room for three large cross-Channel steamers to be berthed together alongside the quay at all states of the tide.

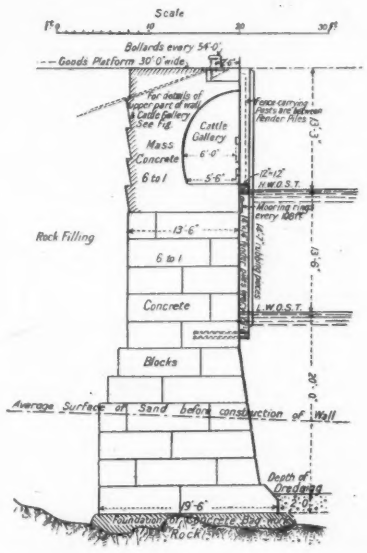


Fig. 7—CROSS SECTION OF IRISH BOAT QUAY WALL

The passenger station and yards.—The cross-Channel passenger station, which has been constructed behind the quay wall, is shown in the plan, Fig. 2, and a cross-section is given in Fig. 9. The Supplement contains views of the station and surroundings taken from various points, one of them being a good general view of the station and harbour from the cliff above the former. The main passenger platform is of the island type, and is 800ft. long. It is provided with the usual waiting and refreshment rooms and offices. Access is given to and from the boats by means of two sets of traversers that bridge the three lines intervening between the platform and the quay. In case any of the intervening lines are occupied so as to prevent the use of the traversers, passengers go through the subway which passes under all the lines and gives access to the quay and to the railway company's hotel and village. The lay-out of the lines and platforms is shown in the plan—Fig. 2—and a detailed description of them will be found in our issue for August 31st, 1906. Since that date a few alterations and additions have been made which are shown in the plan.

There are two goods platforms, and nine 30-cwt. electric travelling cranes, which run on two rails, one laid on the quay wall and the other on a girder carrying one of the station roofs, and supported by steel-built columns. The cranes can plumb the centre of the hold of a vessel having a beam of 50ft., lying at the quay, and are also capable of loading and discharging from and into wagons on either of the goods lines. The cranes have a lifting speed of 250ft. per minute. The goods platform nearest the quay is protected by a low roof covering half its width for its entire length of 890ft. The remaining platforms are covered by a girder span roof 68ft. wide overall, and 470ft. long. At the north end of the quay is a fixed 21-ton electric coaling crane, and three electric capstans are provided. The cattle pen platform is 650ft. long, and contains 65 pens; the fences are made of old rails, and a slaughter-house is provided. Altogether there are upwards of six miles of sidings in the station yard, in addition to the eight main lines of rails. The sidings provide accommodation for 650 goods wagons, and there is ample space for considerable extension when traffic demands it. The traversers to which reference has been made are, when out of use, kept under the platforms and are drawn forward and raised in the opening between the platforms by electric power. There are two sets of traversers, one at either end of the station. When the station has been used for the reception of transatlantic passengers and their baggage the spaces between the platforms have been filled by temporary long wooden platforms mounted on low railway wagon frames which are run along the rails. These movable platforms are several hundred feet long, and, with the fixed platforms, provide when in position a broad level space between the quay and the trains, on which the Customs examination of baggage can be carried out with comfort and expedition.

Power station, electric lighting, &c.—We described the electric power and light station, which is situated at the north end of the yard, in our earlier notice of the works. In the three years that have passed since the description was published there has been very little added to the plant that then existed. It will be sufficient to note that all yards and buildings are lighted by electricity, and electric heating is employed in the buildings. The cranes, capstans, traversers, and other machinery are also supplied with electric power. The railway company has also provided a water supply for the works and the village which has sprung up at the top of the cliff above the harbour, and forms part of the estate of 80 acres which has been acquired by the railway. No less than 120 houses and cottages have already been built by the company for the accommodation of its work-people at Fishguard. A view of a portion of the village is reproduced in the Supplement.

Dredging and anchorage.—The sheltered area of the harbour approaches half a square mile in extent, but a considerable portion of this at the head of the bay is a shallow water area, which is not available for anchorage except for small craft. A portion of this shallow area will be reclaimed when the extension scheme now in progress is completed. The bottom of the bay is soft, and affords excellent holding ground, and the harbour is free from strong currents; the maximum outward flow from the harbour at springs is under $\frac{1}{4}$ knot, and in the approaches the current seldom exceeds $\frac{7}{10}$ knot, the average at springs being well under $\frac{1}{4}$ knot.

An area of about 38 acres in front of the Irish boat quay, where the original depth was considerably under 20ft., has been dredged to a minimum depth of 20ft. at L.W.O.S.T., and the sheltered area, with a depth not less than this figure, is now nearly 90 acres. When the east breakwater is completed and further dredging carried out the deep-water sheltered area will be increased to 150 acres and the enclosed water space to about 175 acres. The total quantity of material dredged from the harbour bed to date is 1,300,000 cubic yards, a portion of this being lifted by a suction dredger and the balance by bucket dredgers and grabs. The deepening of the harbour alongside the ocean quay is now in progress, and in a few weeks there will be a minimum depth of 40ft. at low water available up to and alongside the quay. A large suction dredger hired from the Mersey Docks and Harbour Board is now employed on this work.

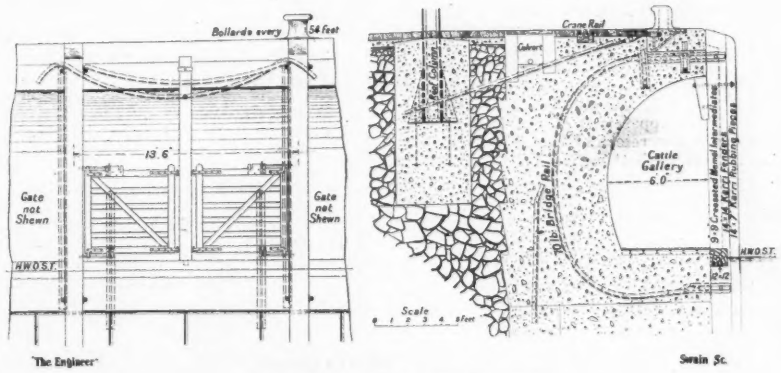


Fig. 8—DETAIL OF CATTLE GALLERY

EXTENSION SCHEME.

The scheme of extension which is now in progress may be divided into two parts for the purpose of description. The first section is the extension of the Irish Boat Quay

* No. I. appeared December 3rd.

to the north-east to join up with the root of the breakwater. The second portion includes the works sanctioned by the Act obtained by the company in the session of 1908, and comprises the construction of a breakwater on the east side of the harbour, the reclamation of a large area of foreshore, construction of wharves and jetties, and the building of a short line of railway to connect the east side of the harbour with the main line.

The quay extension.—Over one-third of this work has already been completed. The new wall will be over 1100ft. in length, and extends from the northern end of the Irish Boat Quay over the bed of the bay in a straight line to a point near the root of the breakwater inshore of the Ocean Quay. The depth of water on the site of the wall averages about 20ft. at L.W.O.S.T. The construction of this wall will add a strip of additional quay space

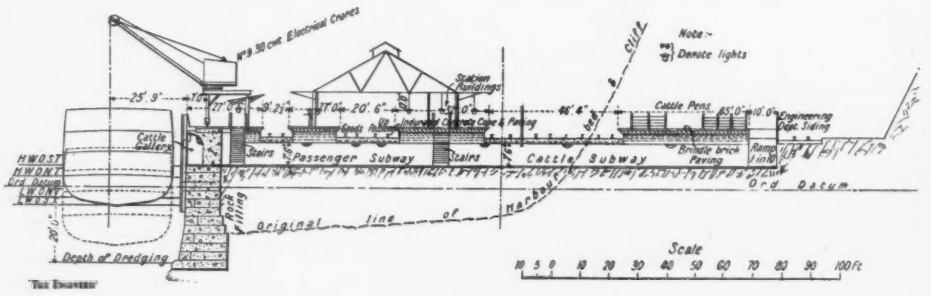


Fig. 9—CROSS SECTION OF IRISH BOAT QUAY AND RAILWAY STATION

1100ft. in length and over 130ft. wide on the average to that already existing. The new quay will be used for both cross-channel and transatlantic traffic.

A cross-section and part elevation of the wall are shown in Fig. 10. The method of construction differs from that adopted for the Irish Boat Quay; no cattle gallery is provided, and the face of the wall above low water is battered 1 in 9. The foundations are prepared in the same manner as those for the Irish Quay. The lowest course of blocks is founded at a level of about 2ft. below dredged level, or 22ft. below low water, and rest upon concrete bag work carefully levelled by divers.

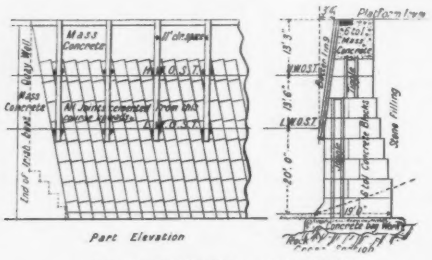


Fig. 10—QUAY WALL EXTENSION

The bag work throughout the work will rest upon rock. The concrete blocks are 6 to 1, and vary in size frm 4½ to 10 tons. The whole of the blocks are laid with sloping bond, the angle being 79 deg. to the horizontal. The sloping courses are 3ft. in thickness, the blocks on the outer face being joggled at the joints thus :—

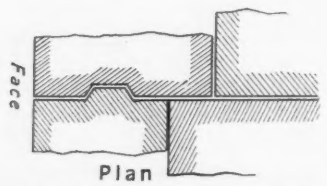


Fig. 11—BONDING OF THE BLOCKS

The wall up to half-tide level is two courses thick, and above that level, to a height of 3ft. 6in. over H.W.O.S.T., every block extends to the full thickness of the wall. The wall has a base width of 19ft., reduced by offsets and batter to a width of 8ft. 9in. at the coping level, which is 13ft. 3in. above H.W.O.S.T., and 48ft. 9in. above the bag work foundation. The upper part of the wall is constructed of 6 to 1 mass concrete, and Jarrah wood fenders 14in. square are fixed on the battered face spaced 11ft. apart in the clear.

The space behind the wall is being filled in with rock *débris* from the quarry, as in the case of the original quay work.

The east breakwater.—A commencement has already been made with the construction of the east breakwater, which will project into the bay in a north-easterly direction from the shore at Goodwick. A glance at the chart —Fig. 1, p. 570—will give rise in the minds of many to the question why the new breakwater has not been planned to run out into the bay, from either Saddle Point or the Castle Point, further to the eastward than the selected site. The adoption of either of these positions for the root of the breakwater would have necessitated the construction of heavy sea walls along the south shore of the bay under Windy Hill, in order to form a reclaimed area for the construction of a line of railway to the breakwater and, in addition, had the breakwater started at Castle Point, the old Fishguard harbour and the approach to the town of Fishguard would have been obstructed. On the other hand, the construction of the inner part of the breakwater on the selected site is a comparatively inexpensive work, owing to the shallow water extending nearly 2000ft. from the shore. The selected site is conveniently situated for railway connection with the main line from Fishguard Harbour to Litterston. This connection is now being made, and the tipping of rubble stone to form the breakwater mound at the root end is already in progress. The breakwater will extend across the bay in a north-easterly direction, and is to be about 5800ft. in length from high-water mark on Goodwick Sands to the head. The structure will be generally similar to the north breakwater, but only at the outer end, where the depth of water is about 40ft. at L.W.O.S.T., will the section be as great as that of the north work.

Reclamation.—The inner portion of the bay between the east breakwater and railway will be reclaimed by the construction of a rubble stone embankment—2145ft. in length—behind which will be tipped dredged material and stone waste. This reclaimed area of about 60 acres is to be utilised for future extensions of sidings, cattle yards, &c., and it is proposed to construct a couple of timber jetties projecting into the harbour from the cross embankment.

Dredging and deep-water quays.—The enclosed water area, after the completion of the east breakwater and reclamation, will be about 175 acres, and those portions where the water is now shallow will be deepened as required to meet the development of traffic. About 100 acres will have a depth of 40ft. and over, and 150 acres will exceed 20ft. in depth. Deep-water quays for transatlantic traffic, similar to the quay already built on the north breakwater, will probably be constructed along some part of the east breakwater, but the details of this part of the work have not yet been settled.

EXPENDITURE AND STAFF.

It may be interesting to give a few particulars of the cost of the work, in addition to those we have already mentioned in connection with the breakwater. The total expenditure of the railway company at Fishguard up to the present time is a little under half a million sterling. This sum includes all engineering and administration expenses in connection with the works and the whole of the construction and plant in and about the harbour, as well as the railway works north of Goodwick Station, which is situated at the southern or inner end of the bay, about a mile from the harbour station. In addition to the works we have described in some detail, there are many others which we have only just touched upon, such as the power station, marine department workshops and stores, the village, water supply, and plant, the cost of which is included in the total. The cost of that part of the scheme of extensions which has already been carried out, including the construction of a considerable portion of the quay extension, is also included. When the east breakwater reclamation and jetties are completed the expenditure will probably have reached to over £1,000,000.

With the exception of a large portion of the blasting work, the labour on which was let as a piecework contract, and some of the labour on the quay wall, practically the whole of the work has been carried out by departmental agency under the direction of Mr. J. C. Inglis, Pres. Inst. C.E., the general manager and consulting engineer to the Great Western Railway Company. When the railway company took over the works in 1898 they had already been in progress for about two years, under the direction of Mr. I. J. Mann, M. Inst. C.E., as resident engineer. Mr. Mann continued in this position until 1902, when the small boat pier had been constructed, a commencement made with the breakwater, and an area cleared at the base of the cliff sufficiently wide to enable steam plant to be employed with advantage. On Mr. Mann's retirement Mr. G. Lambert Gibson, M. Inst. C.E., was appointed resident engineer, which position he continues to hold. His chief assistant for some years has been Mr. A. H. Clark, Assoc. M. Inst. C.E.

Correction.—The figure 3200 in the cross-section of the Fishguard breakwater, Fig. 3, in our last issue, should read 13,200 square feet. The cost of the breakwater per cubic yard of the work is 3s. 2d., and not 14s., as given in the last paragraph of the article on page 572.

IRRIGATION WORK OF THE UNITED STATES GOVERNMENT.

No. VIII.*

MISCELLANEOUS.

The Okanogan district.—The Okanogan irrigation district, in Washington, is in a region remarkable for its mild climate, and this region extends north into British Columbia. While there are places in the north-west where a temperature of 50 deg. below zero is known, this particular section—sheltered by hills and open to the warm winds—has a genial and equable climate. It has ideal conditions for fruit growing, both as to fertile soil and mild climate; in fact, it is said that there never has been a "killing" frost to damage the fruit crop. Under such conditions farmers are naturally willing to pay charges much higher than usual for the privilege of a constant and ample supply of water, and the introduction of irrigation has caused a marked increase in the price of land. The irrigation district has an area of nearly 12,000 acres, the soil being largely volcanic ash, sand, and gravel. It is 1000ft. above sea level, with an average rainfall of 8in. per year, and with a temperature range from 10 to 105 deg. Fah.

The Salmon River is closed by a dam to form a storage reservoir of over 400 acres in area, with a capacity of 13,000 acre-feet. This dam was built by the hydraulic system, as described below. An outlet tunnel of reinforced concrete, 6ft. by 6ft. in section, discharges the water into the river channel below the dam, and it flows about

Fig. 53—CONCRETE-LINED CANAL

12 miles to a point where the channel is crossed by a concrete diversion dam, or weir, with headworks for the main irrigation canals. There are 60 miles of main canals, ranging in capacity from 100 cubic feet to 30 cubic feet per second. Fig. 53 shows a part of one of the canals, cut through rock and lined with concrete to give a steady flow. The capacity of the small smooth channel is equivalent to that of a much larger channel with rough sides, so that a good deal of rock excavation was avoided in this way.

The Salmon River storage dam is 1050ft. long on the top, 865ft. long on the bottom, with a height of 60ft. above the ground, or 50ft. at the wasteway channel, which is 180ft. wide, cut in the rock. The top width is 20ft., with a slope of 3 to 1 on the water side and 2 to 1 on the rear side. Beneath the dam is a line of sheet piling, driven to a depth of 33ft. The body of the dam is of earth and gravel washed from the hillside by powerful jets of water, the material and water flowing down long lines of wooden flumes or troughs to the site of the dam. The main flumes were lined with steel, and laterals were extended as required. By careful methods of excavation

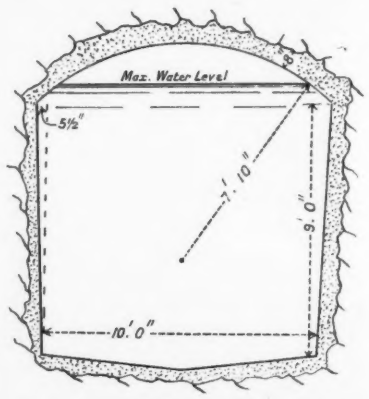


Fig. 54—TUNNEL ON IRRIGATION CANAL

and of sluicing or washing the material into place the finer material was kept in the middle portion, with gravel on each side, and coarse gravel and loose rock on the outer portions. There is practically no clay in the work.

The Strawberry Valley District.—This irrigation district, in Utah, includes about 60,000 acres at an elevation of 4500ft. above sea level. The soil is sandy loam and gravel, with deep black loam in the bottom lands. The annual rainfall is about 18in. Artesian water is found at many points, and is used for domestic supply. Water for irrigation will be drawn from a reservoir—30 miles distant—formed by a rock embankment dam across the Strawberry River. This dam is 42ft. high. A tunnel four miles long, driven through the mountains forming the rim of the "great basin," will carry the water to Spanish Creek, from which a main canal 20 miles long will extend to the irrigated lands. In earth the canal is 16ft. wide on the bottom, with side slopes of 1½ to 1, and 6½ft. depth of water. Its capacity is 500 cubic feet per second, and the velocity 3ft. per second. In rock, the

* No. VII. appeared November 26th.

canal has a bottom width of 9ft., with slopes of ½ to 1; the capacity is the same, but the velocity is 6.3ft. per second.

The tunnel is shown in Fig. 54, and has a gradient of 3 per 1000. A steep mountain ridge rises 1500ft. above the tunnel, and a road twenty miles long had to be built through difficult country from the nearest railway to both ends of the tunnel. The gradients are from 1 in 20 to 1 in 28, with curves so laid out as to allow the use of six-horse teams. Water power from a high-level canal is used for the generation of electric current, which is transmitted to the tunnel and used for operating the air-compressors, narrow gauge locomotives, and other machinery. When the tunnel is completed, the electric current will be used to operate pumping plants to raise water for the irrigation of a track of land above the level of the water supply system.

The Klamath District.—This irrigation district comprises lands in California and Oregon, and has as a special feature the combination of both irrigation and drainage. A number of lakes and large swamp areas are included within the district, and these will be drained so as to give additional area for cultivation under irrigation. The south canal is 15ft. to 18ft. wide on the bottom, with side slopes of 1½ to 1. One of the smaller canals is partly in embankment, and has the part immediately under the canal built in 6in. layers, each sprinkled and rolled. This forms 60 per cent. of the embankment. The triangular side portions were built in 12in. layers. Most of the material in excavation was earth that could be ploughed by six-horse teams. Some indurated material required blasting before it could be removed with horse scrapers. Another work is a timber flume or open rectangular conduit built on trestle work. This is 4300ft. long, 11ft. wide, and 6ft. deep.

The Carlsbad District.—This district in New Mexico presents an interesting feature in a large dam of peculiar construction, replacing a private company's dam which was breached by a flood in 1904. The Avalon Dam across the Pecos River is 1350ft. long, 50ft. high above the river bed. A concrete core wall is built on the rock, but does not reach to the top of the dam, the upper part of the core being a steel plate diaphragm anchored to the concrete as shown in Fig. 55. The up-stream part of the dam is an earth embankment, and in this the core wall and steel diaphragm are embedded. The down-stream portion is a loose rock embankment. The district has an area of 20,000 acres at an elevation of about 3100ft. above sea level, with an average rainfall of 12in. per annum.

The Yakima District.—This district, in Washington, on the Pacific slope, will provide for the irrigation of a series of valleys in the drainage area of the Yakima River, the total area being nearly 500,000 acres. A very extensive system of works has been planned by the Government engineers, and the cost will be about £3,000,000. The works will be taken up in divisions, however, each providing for a complete system for a certain part of the lands. Existing private irrigation systems in the district have been purchased by the Government, and will be worked into the more comprehensive system. The soil is largely volcanic ash and loam, and there is an annual rainfall of 7in. to 9in. The elevation above sea level is from 650ft. to 2000ft. A storage water supply is to be obtained by building dams at the outlets of several mountain streams, giving a combined capacity of 805,000 acre-feet. One of the interesting structures is a concrete wasteway conduit carrying off the surplus flow in a main canal. This is shown in Fig. 56. It is partly a trapezoidal section, and partly a semicircular section of 8ft. diameter, the latter in rock cutting. At intervals there is an 8in. cut-off wall, 2ft. deep, to prevent water from creeping along the bottom, and drainage is provided for by a pipe laid in a trench filled with coarse gravel.

The St. Mary's District.—We close this series of notes with the following reference to the main canal of the St. Mary's irrigation district in Montana. Some of the sections in cutting and embankment are shown in Fig. 57. This shows also the culverts of 24in. concrete pipe, made in 24in. lengths, and laid with mortar joints. The end sections are flanged to form portals, and some of these flanged pipes are used along the culvert to prevent water from working along the outside of the culvert.

The canal has a capacity of 850 cubic feet per second, and its dimensions are as follows:—

Section.	Bottom width.	Depth of water.	Area in square feet.	Side slopes.	Velocity in cubic feet per second.
	ft.	ft.			
1	7	6½	98	1½ to 1	8·66
2	7	6½	98	1½ to 1	8·66
3	14	8	144	½ to 1	5·80
4	27	8	312	½ to 1	2·70
5	27	8	312	1½ to 1	2·70

PRESENT CONDITIONS OF THE WORK.

A brief review of the present condition of the work on the several irrigation districts described will be of interest, this review representing the progress up to August last.

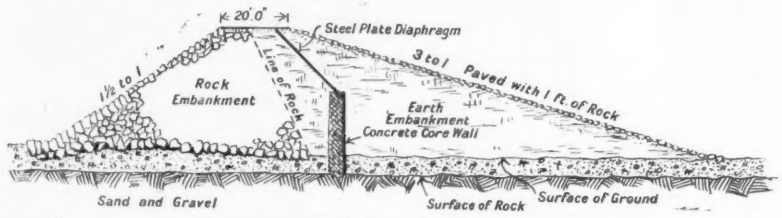


Fig. 55—AVALON IRRIGATION DAM ON THE PECOS RIVER

1. *Shoshone District.*—The work as a whole is nearly half completed, and the great dam is 78 per cent. finished. On July 3rd the highest known flood in the river occurred, amounting to 17,000 cubic feet per second, and flowing 17ft. 4in. deep over the unfinished dam, which sustained no injury. About 7000 acres are already being irrigated.

2. *North Platte District.*—About 74 per cent. of the work for this district is completed, and the main Interstate canal is carrying 1200 cubic feet per second.

3. *Salt River District.*—The work is 82 per cent. completed, and the same applies to the great dam. The main canal is being finished, while the electric transmission line and sub-station are completed.

4. *Belle Fourche District.*—The work as a whole is 70 per cent. completed; the main embankment being 75 per cent. finished. In July 85,000 cubic yards were deposited, making a total of 1,221,000 cubic yards, and 1250 concrete blocks were laid to pave the water slope.

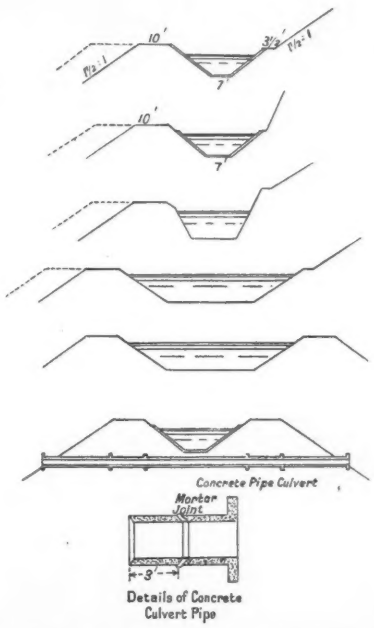


Fig. 57—SECTIONS ST. MARY'S CANAL AND CULVERT PIPE

A railway branch line is being built through the district.

5. *Minidoka District.*—The gravity system is completed, and the pumping system 57 per cent. The hydro-electric station is under construction.

6. *Payette-Boise District.*—This is 79 per cent. completed, and work is being finished on the distributing canals, so that water can be delivered next season.

7. *Huntley District.*—The works are 96 per cent. completed, and water is being distributed.

8. *Williston District.*—The works are 66 per cent. completed, and the power-house, pumping plants, and canals are in operation, supplying water from the Missouri River.

9. *Buford District.*—The works for this district are 38 per cent. completed.

10. *Garden City District.*—The works are 96 per cent. completed, and the pumps are in operation at the wells.

11. *Uncompahgre District.*—The headings of the six-mile Gunnison tunnel met July 6th, with variations of 0.04ft. centre line, 0.32ft. in gradient, and 0.86ft. in distance. The tunnel is 81 per cent. completed, and the entire work of the district 52 per cent.

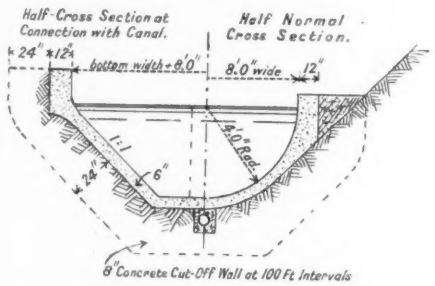


Fig. 56—SULPHUR CREEK WASTEWAY

12. *Truckee-Carson District.*—The works are 90 per cent. completed, and the water stored in Lake Tahoe has been turned into the Truckee River, whence it is diverted to the main canals.

13. *Yuma District.*—The Laguna Dam is finished, and the general work is 71 per cent. completed.

14. *Okenogan District.*—The dam built by sluicing is 68 per cent. finished, and the work as a whole 94 per cent. finished.

15. *Strawberry Valley District.*—The works are 34 per cent. completed, but the work on the main tunnel is only 14 per cent. finished, with an advance of 306ft. in July.

16. *Klamath District.*—Work is 38 per cent. completed, and water is being supplied to the first unit of 20,000 acres.

17. *Carlsbad District.*—This is completed, but the quantity of water stored by the dam is not yet sufficient to meet the demands.

18. *Yakima District.*—The works are 67 per cent. completed on the Tieton and 37 per cent. on the Sunnyside sub-district.

19. *St. Mary District.*—Work is 18 per cent. completed, and the excavation of the main canal is in progress.

THE WORKS OF DRYSDALE AND CO., LIMITED, YOKER, GLASGOW.

THE firm now known as Drysdale and Co., Limited, commenced business as engineers in Glasgow in the year 1874. Mr. J. W. W. Drysdale, the principal of the business to-day, had at that time associated with him as partner the late Mr. Louis Pirie, and the firm was consequently styled Drysdale and Pirie. In 1884, on the death of Mr. Pirie, the name of the firm became changed to Drysdale and Co., and when in 1908 it was necessary to acquire a new site for the works the company assumed its present designation. The works were at the beginning of the firm's career situated in Fordneuk-street, in the east of Glasgow, and here for 34 years the manufacture of all varieties of centrifugal pumps and their associated engines were carried out. An increasing demand for the company's products entailed a corresponding increase in the workshop capacity, and when the natural limitations of the original site had been reached as far as farther extension was concerned, it was determined to acquire a new situation for the works, and to build new and up-to-date shops.

The position ultimately chosen for the farther enterprises of the firm was on the right bank of the river Clyde at Yoker, a district which had already attracted the favourable attention of several other engineering firms. To this new ground the tools and plant of the company were transferred during the New Year holidays and the next few weeks of 1908.

The expedition and careful direction of the removal reflect great credit on Mr. Wm. Drysdale, the works manager, and son of the founder of the firm. Before commencing to remove, the new power plant, shafting, cranes, &c., had been installed in the Yoker shops, and for some time preceding the date of changing, late working in the old shops had been resorted to, thus keeping the work in hand at the time well ahead. All the foundations for the tools having been prepared in the new shops, the actual removal was commenced in the last week of 1907. A double shift was worked at both ends throughout the change, and during each day sufficient material was carted to the Yoker shops to keep both the day and night shifts at that end fully employed on its installation. As a result of the careful organisation given to all details, at the end of January, or in about five weeks from the commencement, everything had been removed from the old works, and the greater part of the new works had been running for about a fortnight. It is estimated that on account of the removal no work on hand at the time suffered a delay greater than that of a week. As soon as any machine had been fitted up on its new site it was worked by two shifts, and this arrangement largely contributed to the reduction of time lost.

The general arrangement of the new works will be gathered from Fig. 3, where it will be seen that the shops consist of five bays varying in width from 25ft. to 40ft., and having a length of about 220ft. The axes of the bays run parallel with the direction of the river Clyde at this point of its course, a space of sufficient extent to permit the erection of two 25ft. bays and one 30ft. bay having been left between the shops and the river for future extensions. On the east the site is bounded by the ground belonging to the ship repairing works of Messrs. J. Shearer and Sons; to the west, the extensions of the future have been fully provided for. On the side lying inland from the river the site has for its boundary the Balloch branch of the Caledonian Railway Company's system, and from this a line is led into the works. A road runs between the railway and the works, and facing on to this are the office buildings, where the commercial and drawing departments are engaged. Adjacent to the offices, and with its frontage also to the road, is the pattern shop, a well-lighted building fitted with all modern tools for the production of the high-class and intricate patterns requisite in the pump-making industry. A large three-storey pattern store close to the pattern shop lies at right angles to the road on the east boundary, and to this a fourth floor may be added if desired in the future.

Between the above buildings, comprising the offices, pattern shop and store, and the main shops, a space of ground 90ft. in width and running the entire length of the present site has been left. This is sown in grass, and with its cinder paths adds much to the pleasing appearance of the works. Two 40ft. bays will be erected here whenever the workshop capacity has to be increased.

While there are no special machines employed on the company's products, the work being such as is easily accomplished with the ordinary run of tools, we would emphasise the careful manner in which the shops have been laid down and future extensions provided for. The

THE WORKS OF DRYSDALE AND CO., LIMITED, GLASGOW

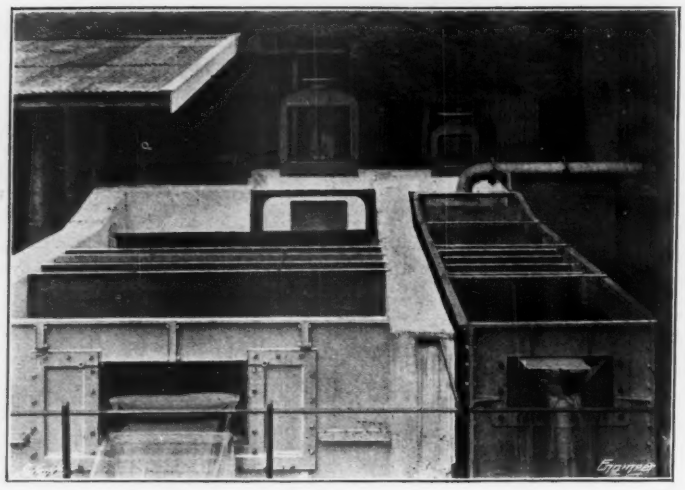


Fig. 1—MEASURING TANKS

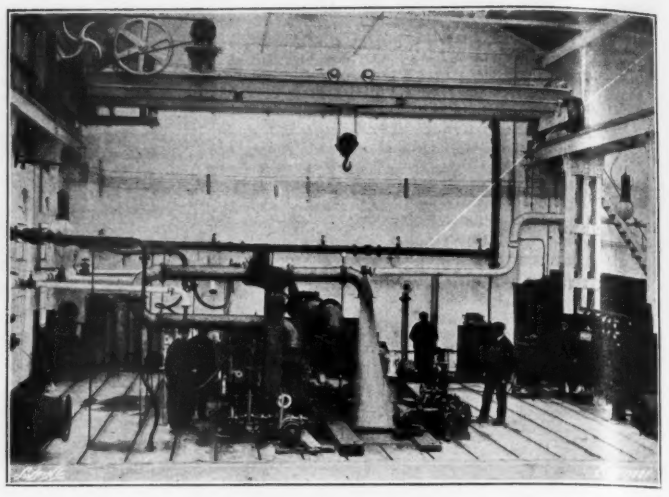


Fig 2—TESTING DEPARTMENT

firm does not undertake its own requirements in castings beyond the supply of the patterns, and as cast material enters largely into the work carried out suitable provisions have been made for its reception, handling, and storage. Parallel with the eastern boundary wall, and at a distance of about 45ft. from it, the railway siding runs across the end of each of the five bays, and is continued out on to the space lying next the river.

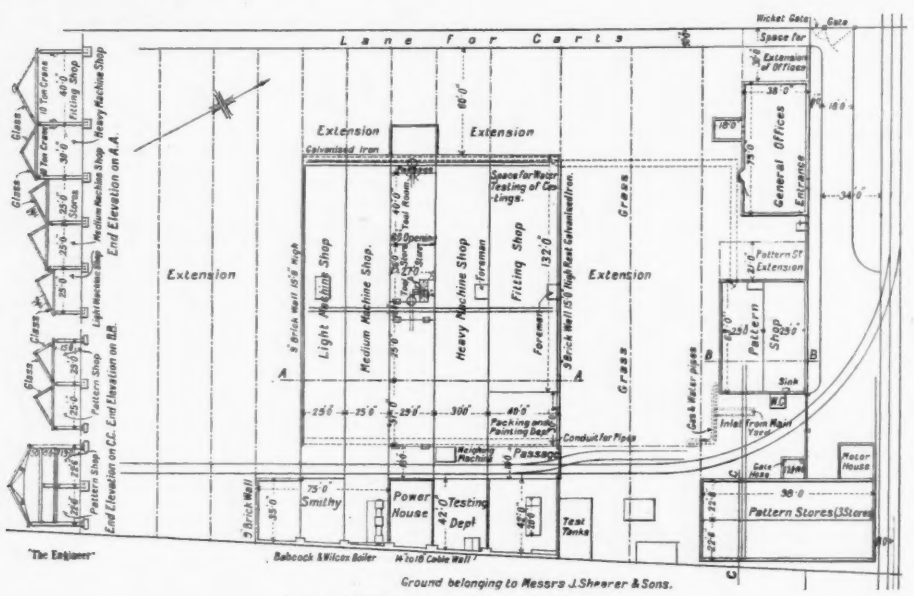


Fig. 3—GENERAL PLAN OF THE WORKS

The ends of the bays thus cut off are utilised as a testing department, casting store, power-house, and smithy, taking them in the direction in which they are passed by an entering truck.

Each bay is occupied by a separate department, the arrangement being such as to require the minimum amount of handling of the material during its passage through the different stages from its entry into the works until it arrives at the testing tank as a component part of the completed pump or engine. The first bay, lying nearest the river boundary, is occupied by the light machines, and is suitably placed relatively to the smithy, where all the lighter forgings required for the pumps and engines are made. In the second bay the medium machines are placed, and at the end it is, like the first, in communication with the smithy. A two ton overhead electric crane, by Messrs. Geo. Russell and Co., Motherwell, serves this bay, the material handled in the first bay being sufficiently light to dispense with a crane service. The third bay is divided into two parts, fenced round with wire netting. A general store occupies the east half bay, a tool and drawing store the west, while the passage left between the two is bridged by the assistant works manager's office, whence an excellent view of most parts of the five bays is obtained. In the general store the finished details are tested and inspected as they arrive from the shops, and are stocked until called for by the erecting shop. The firm has a well-known design of steam engine, which is made in all sizes from half horse-power upwards, and the parts for these, as far at least as standard sizes of the design are concerned, are put through the shops in batches at a time. These parts are all made to limit gauges, while jigs are universally employed. In the general store these details are subjected to inspection, and are held in readiness to meet requirements at the shortest notice. The tool store looks after the supply and maintenance of the entire stock of tools used on the machines, and is provided with suitable tool grinders.

Heavy machines occupy the fourth bay, which has the castings store situated at its end. A ten-ton overhead electric crane, by Royce, of Manchester, serves this bay, and as it runs along the entire length it can be used to discharge wagons arriving at the east end. The machines in this shop include large vertical and horizontal boring mills and lathes, and are for the most part independently electrically driven.

Fitting and erecting are carried out in the fifth bay, which is worked by a 10-ton electric and a 2-ton hand overhead crane. At the west end of this shop provision is made for the hydraulic testing of the castings as they are delivered from the machine shops. Passing down the bay the space is devoted in turn to the fitters' benches, painting, and packing department, and on the east side of the railway lines to the testing department, where the performance of every pumping set is determined.

Throughout all departments a concrete floor has been laid down, a comfortable footing for the workmen being provided at the benches and elsewhere by 3in. by 1¼in. planking. Two sets of narrow gauge lines for the works bogies run across the shops, one set being laid at the western end, the other running across at the centre, and passing between the tool and general stores.

The provisions for testing the completed sets of pumps and their engines are elaborate, and the measuring weirs, which were installed only a few weeks before our representative visited the works, call for especial mention. At the end of the fifth bay, as already mentioned, the testing department is situated so that the final stage in the construction of the pump is reached at a point close to the railway siding, and therefore suitably placed for dispatch. The testing details comprise a tank 20ft. by 8ft. by 14ft. to 17ft. deep, whence the pumps during a test draw their supply of water. Along one side of this tank provision is made for the testing of steam pumps, a full range of pipes supplying steam at any pressure up to 300 lb. per square inch and the necessary exhaust pipes being found here. On the opposite side of the tank the electrically driven pumps are tested, and for this purpose alternating current at any pressure up to 600 volts is available, while the neighbouring power station of the Clyde Valley Electrical Power Company can be drawn upon for further supplies.

For ordinary shop tests water meters are used to measure the output from the pumps, but some months ago the firm determined to fit up a very complete measuring apparatus on the notch principle. Two measuring tanks have been laid down just outside the main shop buildings and close to the testing tank, and in Fig. 1 we reproduce a photograph of these while running. The larger tank is constructed with concrete walls and cast iron front, and has a maximum capacity of 12,500 gallons per minute. For smaller flows the rectangular notch giving the above flow can be replaced by a smaller one with a maximum capacity of 3500 gallons per minute. The method of interchanging the notches will be seen from the figure, where the smaller notch is shown in action.

For still smaller flows the second tank is used. In this case the side walls of the tank are made of galvanised sheet iron, the front being again of cast iron. A V-notch having a maximum capacity of 600 gallons per minute, and a rectangular notch, with a capacity up to 1250 gallons, can be fitted at will to the front of the small flume, so that with the two tanks a very full range is provided for. Each flume is fitted with four perforated vertical baffles, and, as will be seen from Fig. 4, where a sectional elevation of the large tank is shown, the water, as it enters through the sluice valve from the distributing box, is stilled and strained first by a horizontal sieve, then by a fixed vertical baffle descending to within 2ft. of the tank bottom, and finally, before reaching the first of the four baffles, by a horizontal wooden float working in four guides on the side of the tank. In order that both tanks may be used simultaneously, a pipe 9in. in diameter is

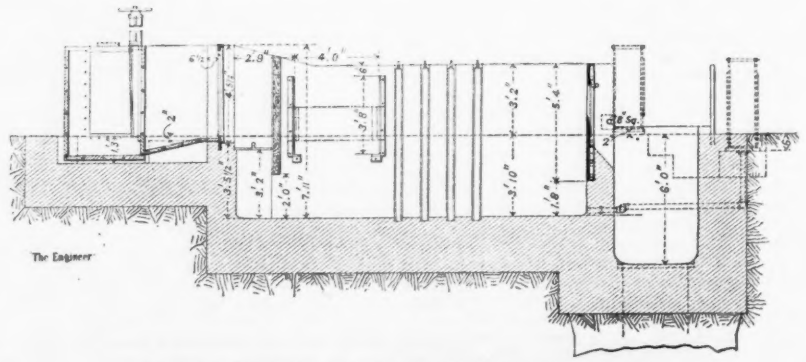


Fig. 4—LONGITUDINAL SECTION OF LARGE MEASURING TANK

led from the testing tank inside the workshops, and delivers water to the smaller flume on the down-stream side of the sluice valve.

As the water falls over the notches it is taken away by a sump in communication with the testing tank inside the adjacent building. To measure the head of water over the weirs a 4in. pipe is led from the front of each to instruments within the workshops. The pipes thus led away are in communication with the tank at its lowest level, and at this depth the water is practically still. Hence in the measuring instruments the level recorded is the true statical head over the weir—that is to say, they record the height of water as if it were measured at a distance sufficiently far up-stream from the notch to prevent the result being vitiated by the velocity of the water as it flows over the crest. The instruments employed for measuring the head are of the float gauge type, and were supplied by Kelvin and James White, Limited. For the rectangular notches Francis' formula is employed, the values of the constants involved having been carefully determined on the experimental notch of similar proportions in the James Watt Engineering Laboratories at Glasgow University. For the V-notches the ordinary single term formula is used.

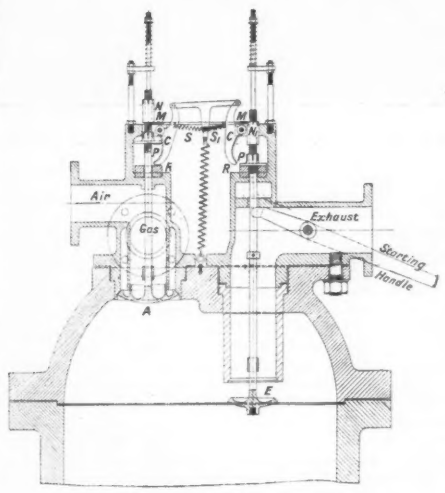
Drysdale and Co., Limited, make a large range of centrifugal pumps, and with the high-speed steam engines associated with their name their pumping sets are widely known, being employed for such purposes as supplying cooling water to condensers, sand dredging, ship salvage work, irrigation, and many other uses in all parts of the world. On page 606 we give some views showing the interior of a few of the departments.

IMPRESSIONS OF THE HUMPHREY PUMP.

A WELL KNOWN waterworks engineer who went down to Dudley Port to see the Humphrey pump at work, after looking at it for some time, observed with a sigh: "Well, I suppose we've got to have it, but it will make a —— ugly engine-room." That remark sums up not inaccurately a good deal of modern power engineering. The turbine has robbed the engine-room ashore and afloat of much of its interest and beauty—one soon wearies of watching a Russian iron casing even when it *is* neatly finished with brass bands; and now comes the gas pump to deprive us, we are told, in due course of the great engines whose dignified comportment it was a privilege to witness. The Humphrey pump is nothing at all; just a pipe with an air chamber at one end and an explosion chamber at the other, the latter surmounted by a few fittings, which, by their periodical intermittent motion show that the thing is really alive. But it is, nevertheless, one of the most interesting inventions in power engineering that has been seen since the dynamo astonished the world, and we believe a short account of an inspection of the experimental apparatus in its latest form will not be without interest.

In our issue of October 22nd we described and illustrated the plant that was tested by Professor Unwin. The explosion chamber used then was a conical vessel bolted to the cylindrical water valve box. Its capacity was such that the pump might be described as of 16 pump horse-power. It has now been replaced by a larger chamber, which, instead of being conical, is a plain cylinder made of two flanged cast iron rings bolted together. It is made in two parts simply in order that the volume of the chamber may be reduced for experimental purposes by removing one ring. This cylinder stands upon the original water valve box, and it works at the disadvantage that its capacity is too great for the valve area, and hence the number of strokes has to be few to enable sufficient water to enter. As a matter of fact, when we saw the pump at work a few days ago, it was making eight cycles a minute, or not more than half the speed it will attain when its own valve-box is fitted. The cylinder is closed by a domed top, in which are situated the three valves for admission, exhaust, and scavenging. A section of the two former is shown herewith, which illustrates the actual apparatus now at work. The admission valve, it will be noticed, is near the summit of a chamber, which in plan is kidney shaped, whilst the exhaust valve is placed a good deal lower. The action of the valves is extremely pretty, because it is entirely automatic and without any actuating mechanism whatever, the original attachment with the water valve having been given up. In the position shown it may be imagined that the exhaust has just opened by its own weight, and the products of combustion are being driven out. It is required at this stage to hold the admission valve up, and this is effected by the steel plate or bolt M M., which is free to slide sideways. As shown, one end of it projects beneath the nut N on the admission valve spindle, and prevents that valve from falling. It will be observed that the spring S is in tension tending to pull the plate to the right, whilst S_1 is slack. Suppose now that exhaust is complete and the returning water has struck E and raised it against its seat. As soon as the nut N_1 is raised high enough, the plate M is pushed under it by the tension of the spring, and the valve is held up. At the same time the admission valve is left free to fall. It does not do so at once, because the pressure in the chamber is keeping it on the seat, but as soon as the water retires it drops by its own weight till the plate P strikes the rubber pad R, and is then full open for the admission of air and gas. But during its fall the lever C is pushed over, on account of its cam face bearing against the plate P, the result being that the tension is now put on spring S_1, and the plate M M is ready to shoot back under N when the valve is again raised. This takes place on the compression stroke, but though the exhaust valve is then free to fall, it is supported by the pressure in the chamber until expansion is complete, when it drops by its own weight. It will be noticed that in both valves the seat is at the bottom of a short cylindrical part, so that even before the valve seats the aperture is practically closed, and there is no waste of gas when the valve seats. Scavenging is effected in this way. After the explosion has taken place, and the water is moving outwards, as soon as the pressure gets below atmosphere the scavenging valve is sucked open and fresh air is drawn into the cushion chamber. This air does not mix much with the products of combustion, but lies on top of them. Then when the water returns it drives out the products through the exhaust valve, but entraps the fresh air in the cushion chamber. Hence all the products of combustion, except the very small portion which may have mixed with the scavenging charge, are driven out. In the ordinary course, to ensure that the air enters by the scavenging valve, and not simply back through the exhaust—in which case if the exhaust pipe were long the products of combustion lying in it would be drawn back—a non-return valve is put on the exhaust. When, however, we saw the pump, scavenging was not being employed, because the water valve area being so small, all the suction obtainable was needed. The non-use of it appeared, however, to make no difference to the action of the pump, which exploded with absolute regularity and with great certainty.

It was originally expected that ignition would give trouble because the points were being continually soused with water, and a large Lodge ignition apparatus was at first employed, and may still be seen in the engine-house. It was, however, found that by a simple modification of the ordinary commercial ignition plug an ordinary trembler coil and battery, such as are used on a motor cycle, would do all that was required, and are now always used; but in order to be fully up to date a magneto operated by the timing gear is now being made, and will be tried shortly. The timing gear is one of the most ingenious details of the whole apparatus. The object to be obtained is to fire the products at the very instant when compression has reached its maximum wherever the level of the water may be at that time. This is secured by fitting a miniature piston and cylinder to the cylinder wall; as the compression increases this piston is pushed outwards and pulls one end of a steel band that passes round a small pulley, the other end being attached to a spring. On the pulley is a lever working between two stops quite close together, one of which is the firing contact. As the pulley revolves it draws the lever against the idle stop, and any further outward motion of the piston causes the band simply to



THE LATEST FORM OF VALVE GEAR

slip on the pulley. As soon, however, as the pressure in the cylinder begins to fall the band starts to return and instantly moves the pulley in the opposite direction until the lever makes contact and fires the charge. Full details of the apparatus will be found on page 564 of our issue of Nov. 26th, but we think it worth while to call attention again to this very elegant detail which, it will be seen, absolutely ensures that ignition takes place at maximum compression.

Mr. Humphrey tells us that one of his many visitors made a particular request that he should be allowed to find out how the apparatus worked for himself, and that he studied it for an hour and a-half in the snow and then had to give it up. But if he had had any inkling of the principle involved—the swinging to and fro of the water—he would have found two or three external indicators of what was happening within. As one enters the works the first thing to be seen is the old boiler used as an air vessel—which, by the way, is too small for the present pump, and prevents a high speed being used—and on this air vessel is a pressure gauge the pointer of which tells the whole story of the cycle. You see the needle go up to the maximum, 15 lb. or so, equivalent to the head against which the pump is working; then it falls to 7 lb. or 8 lb. as the air in the chamber expands, driving back the water and forcing out the products of combustion; then it rises again a few pounds as the water on its return swing compresses the air in the air vessel whilst it draws a new charge into the cylinder at the other. Then again it falls whilst compression takes place, and instantly afterwards rises to the maximum as the charge is fired. This dial is a very fascinating detail to watch.

Then the exhaust, too, tells a good deal about the cycle, particularly the fact that expansion takes place down to atmospheric pressure, for it is practically noiseless and quite cold to the hand, though it is accompanied by a cloud of steam evaporated by the explosion. At first one is surprised to find the exhaust so cold, but on consideration it is seen that since it has done all the work it can do, and has been even expanded below atmosphere, there is no reason why it should be hot. The steam, too, is quite cold, and it is a nice point how it exists at all. The whole engine, indeed, works cold, even the breech of the cylinder being scarcely appreciably warm to the touch.

Starting the pump is the simplest thing imaginable. So that we might see the operation, it was allowed to settle down until the water level, as seen in a large gauge glass fixed on the side of the cylinder, was at rest. Compressed air was then admitted, and the water was depressed nearly to the bottom of the glass. Then the exhaust valve was opened for an instant and the pressure allowed to escape quickly; the water immediately rose beyond its level and then fell again, sucking in a charge which it compressed by rising again. At maximum compression the automatic gear ignited the charge and the engine was off. For two or three cycles it appeared to be warming up to its work and then went away with perfect regularity at about eight strokes a minutes.

The thing after all is said and done that strikes one most about the pump is its surprising simplicity. There are literally no working parts in the accepted sense of the word except the few small bits of mechanism that control the valves and the little device for firing on maximum compression. Apart from these, the only things that move are the suction valves, and they are of a very simple nature. There is a large number of these, but they shut so quietly that not a sound is audible outside the casing when they close. It may thus be surmised that they will enjoy a long life. On the other hand, the exhaust valve does go on to its seat with a bang as it is driven up by the water, but it does not appear to suffer from the impact, the fact that it never gets really hot no doubt adding to its wearing qualities.

Of other interesting points about the pump, plenty of information will be found in Mr. Humphrey's paper and the reply he made to the discussion, which will be found on another page. One point of considerable interest is whether the pump can work on a suction lift or not. That it can be made to do so Mr. Humphrey has convinced us, but as patents are pending it would not be right to say anything of the method to be employed at the present time, save that it adds hardly appreciably to the complications of the design.

THE KING'S DOCK, SWANSEA.

No. III.*

The entrance lock.—The entrance lock is placed at the south-western corner of the King's Dock, and is 875ft. long between the pointing sills of the inner and outer gates, and 90ft. wide at coping level. The lock is subdivided by intermediate gates into two compartments, respectively 500ft. and 375ft. long. Over the outer and middle sills there is a depth of water of 40ft. at H.W.O.S.T., and 12ft. at L.W.O.S.T. At neap tides the depths are 32ft. 3in. and 19ft. 9in. at high and low water respectively. Ships drawing 31ft. will therefore be able to enter the dock at high water of any tide in the year, and the majority of vessels using Bristol Channel ports can enter the lock at almost any state of tide, so that for all practical purposes it may be considered a deep water lock. To obtain a greater depth at low water of spring tides would have entailed the dredging of a much greater length of approach channel; the expense of doing this, and the difficulty of keeping the channel clear at a considerable distance from the shore, in an exposed situation, would have been out of proportion to the small advantage obtained thereby. As it is, the depth of 12ft. over the entrance sill at L.W.O.S.T. is greater than that of any other port in the Bristol Channel, at the same state of tide, with the exception of the Barry deep water lock, where the depth at L.W.O.S.T. is 13ft. 9in.

The side walls of the lock are vertical, the upper portions, which are faced with Staffordshire blue brick, projecting over the lower part of the wall, as in the case of the dock wall, which we described and illustrated in our issue of November 19th. The overhang is 6in., and the corbel courses are of granite. The details of the wall-face need not be described further, following as they do the section of the dock wall. The floor of the lock is of concrete throughout, the mass being 6 to 1 with large stone plums, and faced with 4 to 1 concrete. All other concrete faces in the lock are also finished 4 to 1. The invert curve is a flat one, the rise to the sides of the lock being 4ft., and the normal thickness of the floor 8ft. at centre, increasing to 12ft. at the sides. Under the gate recesses the thickness of the floor is increased.

The dimensions of the side walls and other principal features of the lock are shown in the plan and sections—p. 600. In a few minor details the work as executed is at variance with the figures. Notably the swing bridge is skewed to the lock, not at right angles as shown, and the chambers for the hydraulic opening and closing machinery for the gates are not as shown in the drawings. Throughout the work granite—from Sweden—has been used only for the important wearing surfaces, such as pointing sills, caisson chases, roller path seatings; in sluice chambers, openings, and seatings; for corbel courses, copings, hollow coigns, &c. It was originally intended to construct the ladder and chain recesses, and many of the coigns and edge courses in hard Pennant stone, but all these have been built of strong granolithic concrete composed of granite chippings and cement.

At the outer end of the lock a concrete apron has been constructed for a length of 150ft. seaward of the entrance sill, with its surface at the level of the dredged entrance channel, 14ft. below L.W.O.S.T. The east wall of the lock is returned towards the root of the approach jetty, while the west wall is carried out to form a roundhead at its junction with the extension of the old east pier. At the inner end of the lock the west wall terminates in a

* No. II. appeared November 26th.

THE KING'S DOCK, SWANSEA

Fig. 16—ENTRANCE LOCK FROM OUTER END DURING CONSTRUCTION

round head, which will form a part of the entrance to the second lock which it is proposed to construct in the future. This additional lock will probably be 1000ft. in length between the extreme gates and 100ft. in clear width. On the opposite side of the lock, at the inner end, is a corresponding round head. Caisson chases have been formed in the side walls, and stops in the floor of the lock at each end for the reception of ship caissons or timber dams, when it may become necessary to empty the lock for repairs or in case of disablement of the gates. The caisson or caissons have not yet been built.

The main sluices, which are placed in shafts over the main filling and emptying culverts, 6ft. by 10ft., are raised and lowered by direct acting hydraulic presses. In addition to the six main sluices, the lock is provided with four floor sluices, 4ft. by 6ft., for clearing the gate chamber floors of any accumulation of mud. The paddles of all the sluices are of greenheart timber, working on polished granite faces. The culverts are lined with Staffordshire blue bricks, backed with hard red bricks.

The lock—see p. 600—is furnished with eight hydraulic capstans, four of which are capable of exerting a pull of 7 tons, and the other four of 5 tons direct from the barrel.

We have already stated that a temporary stone and sand dam, which formed a continuation of the permanent sea embankment, was constructed across the site of the entrance to the lock between the west end of the sea embankment and the seaward end of the old east pier extension. It was necessary to remove this temporary dam before the completion of the work in connection with the lock in order to permit portions of the work in the approach to be proceeded with. A temporary concrete block dam was therefore constructed across the entrance lock at its outer end, resting on the apron. This second dam also formed an additional protection in the event of any failure of the outer dam. The concrete dam was removed when the whole of the work in connection with the lock had been completed, divers being employed in dealing with the parts below low water. A view of this dam in course of construction will be found in our issue of October 2nd, 1908. The construction of the lock has been favoured by the presence of an excellent foundation, which has enabled the work to be carried out with considerable economy.

Views of the lock in several stages of its construction will be found in our Supplement of November 19th and above. The general arrangement of the lock in relation to its surroundings is shown in the plan of the dock in our issue of November 19th.

Proposed dry dock.—It is proposed to construct a large dry dock on the site adjoining the lock on its eastern side. This work will not be carried out by the Harbour Trustees, but negotiations are in progress with a syndicate for the construction of the dock, plans for which have already been prepared. The dock will have an entrance at either end, and thus be accessible from both the dock and the entrance channel. This arrangement will also permit of its use as an emergency lock, if it should be completed before the proposed second lock. The outline of the proposed dock is shown in the general plan published on November 19th.

The lock gates.—The three pairs of gates are generally of steel and wrought iron, of the water-borne type, and are alike in design, each gate being divided by means of two water-tight decks and a central vertical water-tight bulkhead into five compartments, the lowest of which extends the full length of the gate, and is in free communication with the outer water through openings in the bottom deck. The two compartments above this form the air chamber, and the remaining two are water chambers free to the outer water through open scupper pipes at the top deck of the air chamber, the position of this deck being arranged so as to ensure a proper excess of weight over buoyancy at all states of tide.

Drawings of the outer and middle gates are reproduced in Fig. 17. The details of the inner gates are similar. Two views in our supplement of Nov. 19th show the gates erected in the lock. The underside of the gangway platform is at the level of the lock coping, or 6ft. above H.W.O.S.T. The sills of the outer and middle gates are at a level of 12ft. below low water, or 46ft. below the coping. The inner sill is 5ft. below L.W.O.S.T., so that this pair of gates are 7ft. less depth than the other two pairs.

The gates are flat on the sill side, and curved on the pressure side, 51ft. 9in. long from centre of heel post to centre of meeting face, and 6ft. 8in. in width over the rib angles at centre. The outer and middle gates are 47ft. 5½in. deep, and the inner gates 40ft. 5½in. deep. Those parts of the plating which come in contact with the water, and are inaccessible at low tide, are of wrought iron, the remainder being of mild steel, the thickness of the skin plating varying to suit the water pressures from 1in. to ⅝in., the boundary angles of the ribs and decks varying from 6in. by 4in. by ¾in. to 4in. by 4in. by ½in., and the spacing of the ribs being also decreased from top to bottom. The top, bottom, and two water-tight decks bounding the air chamber are plated throughout, the intermediate ribs being plated at the ends and strongly braced in the centre; in addition to the plated central bulkhead mentioned above plated intercostal diaphragms are provided on each side at a distance of 12ft. 6in., forming continuous stiffeners throughout the depth. Further stiffeners are introduced in the bottom compartment to take up local stresses from the sills, and the ends of the gates are formed with heel and meeting plates 1in. thick.

The heel posts, sill timbers, and mitre posts are of greenheart, all pieces being in one length, secured to the gate by galvanised bolts; the heel posts are stiffened by strong spur plates and angles, and the sills backed by girders securely stiffened from the bottom deck. These greenheart timbers were fitted in position at the works of the builders, and, in order to ensure the greatest possible accuracy in the workmanship of all the meeting faces, the design was arranged to allow of complete sections of the gate forming the heel post, meeting post, and sill respectively being riveted and finished with the timbers fixed and delivered in single pieces, special arrangements being made at the lock for erecting the heavy weights, in some cases as much as 22 tons.

Cast steel pivots and caps are provided at the bottom of the heel posts, the former seated in dovetailed recesses in the masonry, and secured by lewis bolts, and the latter to the gates by fitted bolts, mild steel bearing blocks being interposed between the pivots and caps. The cast steel top pivots engage with forged steel anchor straps carried in heavy cast iron anchor blocks bolted to the masonry and concrete of the top of the quoins, and each further secured by three mild steel land ties carried well back into the wall, and fitted with cast iron washer plates.

Cast iron roller paths with diagonal joints are laid on the floor of the entrance, and on these travel cast steel rollers, 3ft. diameter and 16in. wide, bearing in hinged cast iron carriages, capable of adjustment from the top of the gates by forged steel spears attached to the curved skin. The spears are 6in. diameter, and are fitted with cottars.

The gates are surmounted by platforms of pitch pine, with elm curbs, carried on framed steel supports from the top deck, and provided with hatches giving access to all the interior compartments of the gates through trunks or manholes. Collapsible hand-rail standards, with two tiers of hand chain, are provided on each side of the gangways. Pitch pine fenders or rubbing pieces are bolted to the sea or flat faces of all the gates, both vertically and horizontally.

Levers are placed between the gangways and the top decks to communicate the thrust or pull, as the case may be, of the hydraulic opening and closing machines to an extension of the vertical intercostal diaphragms on the meeting post side of the centre immediately behind the roller spears. These levers, which are of massive proportions, are pivoted to a fixed point on the anchorage vertically above the centre of the hollow quoin, the gate end terminating in a turned pin in a bored hole in the extension above referred to. The point of application of the opening and closing forces is situated at 10ft. 9in. from the swinging centre, at which point a mild steel pin 7in. in diameter is provided to take the end of the connecting rod from the direct-acting hydraulic rams which operate the gates. Details of the opening lever are given in Fig. 18.

Hydraulic ejectors for clearing the air chambers of water in case of necessity are placed on the bottom decks of the air chambers, the suctions being arranged to draw at will from sumps in either of the two compartments. The valves controlling the suctions are operated from the top platforms, the pressure being supplied from dock mains through a swivel union at the top of the heel post.

Each leaf of the outer and middle gates weighs over

220 tons, exclusive of the path, pivot, and anchorage. The inner gate leaves weigh over 186 tons each. All the gates were constructed by the Thames Ironworks, Shipbuilding, and Engineering Company, Limited. The hydraulic opening and closing machinery, which is shown in the general drawing of the gates—Fig. 17—has been supplied by Sir W. G. Armstrong, Whitworth and Co., Limited.

Bridges.—The swing bridges have been supplied by Sir William Arrol and Co. The large skew swing bridge over the entrance lock is 177ft. 6in. long, the long arm being 114ft. 6in., and the short arm 63ft. The clear span is the width of the lock, viz. 90ft. The bridge, which is seen in the view of the lock in our supplement of November 19th, is of the parallel lattice girder type, the clear width between girders being 16ft. A single line railway is carried across the bridge, which is also paved for foot and cart traffic. The weight of the bridge, about 375 tons, is carried by a cross girder under the longitudinal girders, under which again are the rotating drum and the lifting ram. The bridge is lifted and rotated by hydraulic power, and auxiliary hand-power hydraulic presses and hand winches are provided for lifting and rotating respectively in the event of failure of the hydraulic power supply.

The swing bridge over the communication passage, between the Prince of Wales Dock and the King's Dock, is similar to that over the lock, except that it spans a clear opening of 70ft. only, carries a double line of rails, and is of plate girder construction. Its total weight is about 425 tons.

There are several other smaller fixed bridges in connection with the works, among them those spanning the Tennant branch canal on the north side of the dock. These bridges were supplied by Handysides, Limited, of Derby.

Transit sheds.—Two single-storey transit sheds have been erected on the west wharf between the lock and the communication passage—one 400ft. long by 120ft. wide, the other 400ft. by 60ft. They are both steel-framed buildings with steel roofs, the whole covered with galvanised corrugated sheeting. The larger shed is intended for the storage of tin-plates, and the smaller one for tin-plates awaiting shipment. The span of the larger shed next to the quay is to be furnished with an electric overhead crane travelling at high speed with an inverted jib crane suspended from the crab, so as to enable bundles of galvanised sheets to be picked up from any part of the floor and deposited outside the shed, where they will be lifted by wharf cranes and dropped into the hold of the vessel. For this purpose the side of the shed next to the quay is composed entirely of doors which pass one another, so that a load of galvanised sheets can be passed out at any required point. The floors of both sheds are granolithic, with a true, smooth surface for easy barrowing.

Hydraulic power plant.—The Swansea Harbour Trustees have employed hydraulic power for working their dock machinery and cranes for over half a century, and the relative advantages of the system already employed at the docks and electric power were carefully considered by the Trustees' engineers when the time came to decide as to the system to be adopted for the King's Dock. It is unnecessary to enter into the question of the relative merits of the two systems; the pros and cons as affecting Swansea were set forth in much detail by Mr. C. S. Meik in the course of the discussion on dock equipment at the engineering conference at the Institution of Civil Engineers in June, 1907.* The Trustees ultimately decided to install hydraulic power for working most of the machinery of the dock, including the coal hoists, cranes, swing bridges, gate and sluice machinery, and two new power stations have been erected, one at the eastern end of the reclaimed area and the other near the Prince of Wales Dry Dock. The eastern station is equipped with three cross-compound surface condensing pumping engines, each 500 indicated horse-power, and capable of pumping 730 gallons per minute against an accumulator pressure of 750 lb. per square inch. The engines are compound, with cylinders 23in. and 45in., with 36in. stroke; the fly-wheels are 12ft. diameter. Each engine has four force-pumps of the single acting plunger type. A surface condenser is provided for each engine; circulating water is drawn from the dock and delivered into the condenser by a double-acting pump, driven off the main engine, which delivers water through the condenser on the up-stroke and lifts the return water from a well below the engine-room floor into an overhead tank on the down-stroke.

Steam for these engines is supplied by four Lancashire boilers each 30ft. by 8ft., with the adjuncts of Green's economisers, Hotchkiss circulators, auxiliary feed pumps, &c. The power-house contains room for another set of engines and an additional boiler should an extension in the future be required. The Western Station is similar in every respect to the Eastern one, except that it contains one set of engines and one boiler less. The pumping plants have been supplied by Galloways Limited, of Manchester. The pressure water is carried round the dock to the various machines in a main 8in. diameter, made by the British Mannesmann Tube Company, Limited, of solid drawn steel tubing in 36ft. lengths coupled together with wrought steel flanges, spigot and socket, and jointed with the solid gutta-percha rings usual in this class of work.

Cranes.—The whole of the hydraulic cranes in connection with the dock have been supplied by Sir W. G. Armstrong, Whitworth and Co., Ltd., who have also made the hydraulic machinery for working the gates, swing bridges

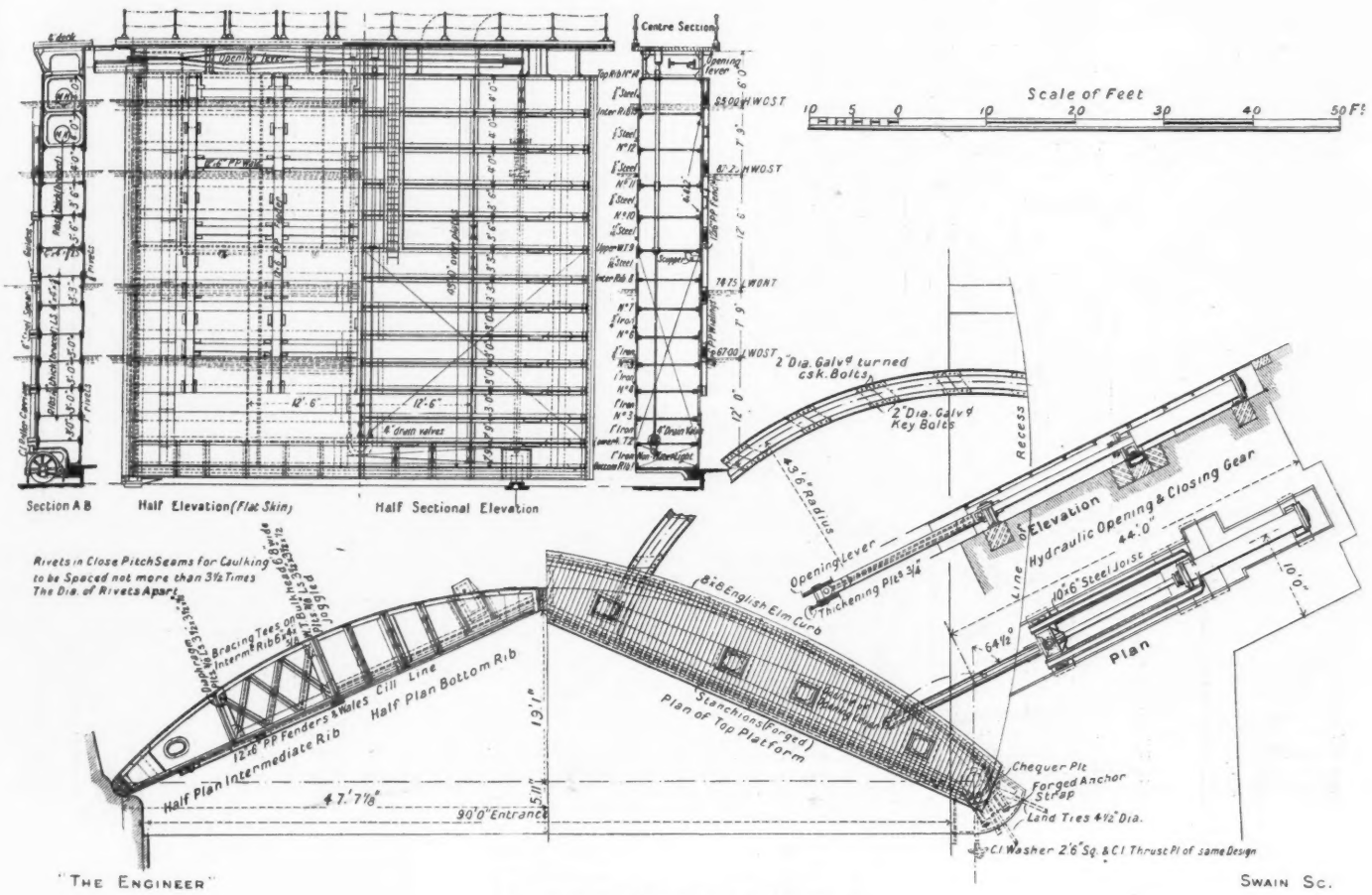


Fig. 17—OUTER AND MIDDLE LOCK GATES

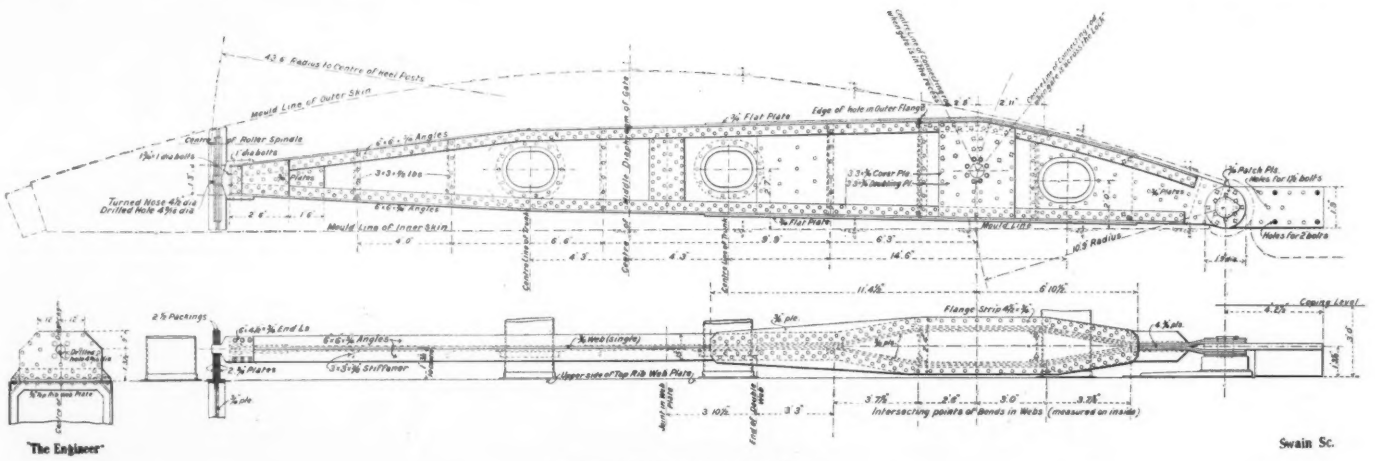
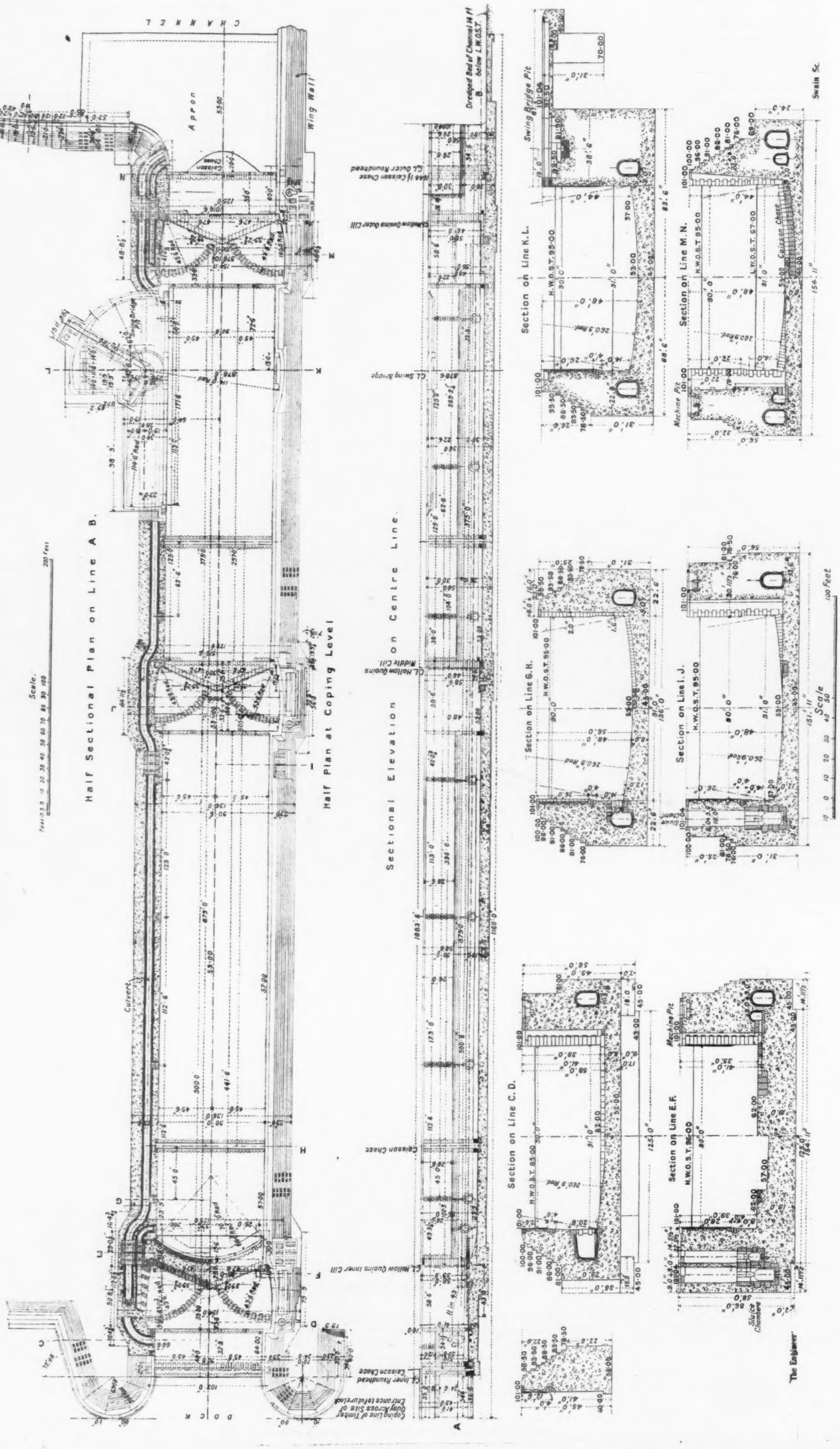

43'6 Radius to Centre of Heel Posts
Mould Line of Outer Skin
Centre of Roller Spindle
Turned Nose 4⅞ dia
Drilled Hole 4⅝ dia
Mould Line of Inner Skin
¾ Flat Plate
Edge of hole in Outer Flange
Mould Lines
10'9 Radius
Holes for 2 bolts
Flange Strip 4½ × ¾
Intersecting points of bends in Web (measured on inside)
"The Engineer"
Swain Sc.

Fig. 18—GATE OPENING LEVER

* THE ENGINEER, June, 1907.

THE KING'S DOCK, SWANSEA—THE ENTRANCE LOCK

(For description see page 597.)



and the lock sluices. At the north-east corner of the dock—see Fig. 3 in our issue of November 26th—a 70-ton fixed hydraulic crane has been erected. The crane, which we illustrate in Fig. 19, is provided with machinery for giving a variable rake to the jib with a minimum of 45ft. radius from the centre and a maximum of 60ft. It is capable of lifting the full load from 30ft. below to 60ft. above quay level. The pedestal is an open braced structure of steel, the four pillars of which are bolted to concrete foundations. The upper portion of the crane, consisting of the jib, framing, ballast box, and machinery, is carried on a steel platform turning about a steel centre pivot, the weight of the moving parts being taken on four steel segments—two at the front beneath the jib, and two at the back beneath the ballast box. These segments work on a ring of live steel rollers revolving on a circular steel roller path secured to a massive circular girder built into the top of the pedestal.

The lifting machinery consists of a hydraulic engine of the three oscillating cylinder type, driving through spur gearing a cast iron drum. The lifting rope, which is 4¾in. circumference, works over a set of four to one blocks in the lifting purchase, the two ends of the rope being led over conveyance sheaves fixed in the jib head to fast ends on the drum, the arrangement being such that the stress is taken equally on eight parts of the rope. The drum has right and left handed machine-cut grooves enabling both ends of the lifting rope to be wound in simultaneously, and the drum is of such a length that no over-lapping is necessary. The lifting gear is provided with two sets of change wheels, the higher gear being capable of lifting the full working load of 70 tons at a speed of 10ft. per minute, and the lower gearing being capable of lifting a load of 35 tons with a corresponding increased speed. Clutches are provided for changing gear, and a powerful brake is also fitted.

The luffing or derricking machinery consists of two direct-acting cylinders bolted to an inclined steel frame at the back of the moving platform, the crossheads of the two rams, which work downwards, being coupled by a solid forged steel beam, to the ends of which are connected a built steel framing or stays attached to the jib head. This luffing crosshead or beam works in steel guides and is fitted with gun-metal sliding faces. The turning machinery consists of a separate three-cylinder hydraulic engine actuating through spur and bevel gearing a steel pinion engaging with a turning rack, which is attached to the lower roller path. A special brake is fitted to the turning mechanism to lock the jib in any position. The speed of turning is 135ft. per minute, measured at the jib head at maximum rake. A large steel ballast box is provided at the rear of the revolving platform, and contains ballast sufficient to relieve the centre pivot and holding down bolts of any undue strain.

Fig. 19—70-TON HYDRAULIC CRANE

A 10-ton movable hydraulic crane is provided on the west wall of the dock. This is of the arched pedestal type, running on rails of 13ft. gauge, with a 13ft. wheel base. Hand travelling gear is provided at all four corners for moving the pedestal along the rails. The lifting machinery is of the ordinary pillar type, where the lifting cylinder and ram are contained between the pillar plates. The rake is 50ft., and the range of the lifting hook 60ft. Sixteen 2-ton movable hydraulic cranes, with fixed rake, are placed on the west and east walls of the dock. These are practically similar to the 10-ton crane, excepting as regards their power, the rake and range of lifting hook being identical in each case. On the south wall of the coaling arm four 2-ton movable cranes are provided, with luffing machinery, consisting of an inverted cylinder and ram attached to the back of the pillar. To either end of the ram crosshead are attached two wire ropes, led over conveyance sheaves at the top of the pillar to the jib head. The maximum rake of these cranes is 50ft., and the minimum 30ft. In all other respects these cranes are the same as those of fixed rake on the west and east walls.

The whole of the cranes, with the exception of the 70-ton fixed crane, are of the pedestal type, allowing trucks and vans to pass through underneath.

Electrical equipment.—An electrical plant is now being installed by the Harbour Trustees for the supply of electricity for lighting and power for their own use, and that of works, &c., on the estate. It is proposed to utilise electric power for light high-speed cranes and other machinery, hydraulic power being employed for the heavier duties. The electric plant consists of Willans-Peebles turbo alternators; sub-station equipment by Crompton and Co., Ltd.; and Lancashire boilers, economiser and superheaters by H. and T. Danks, Limited. The system of supply is 3000 volts, 50 periods, three-phase alternating current. This current will be used for motors of over 50 horse-power, and transformed down to 460 volts for motors under 50 horse-power. The current for lighting will be supplied from the various sub-stations. The high-tension current will be transformed down, by means of motor generator sets, to 250 volts direct current.

The dock quays, main roads, sheds, warehouses, &c., will be lighted by arc and incandescent lamps. Electric cranes are being erected in the sheds for transhipping the goods from the sheds to the quay, and electric cranes are to be installed on the quays of a similar type to the hydraulic cranes for the loading and unloading of ships. An electric transporter is also to be used for the transhipment of pitprops, iron ore, &c., direct from the ships to the unloading ground.

Conclusion.—The total cost of the new works when fully equipped with coal-handling appliances, warehouses, and machinery will be about £2,000,000. Mr. P. W. Meik, M. Inst. C.E., of Westminster, and Mr. A. O. Schenk, M. Inst. C.E., the engineer to the Harbour Trustees, are jointly responsible for the design and execution of the work, for which Messrs. Topham, Jones and Railton, Limited, of Westminster, are the general contractors. Mr. R. S. Oldham, M. Inst. C.E., is the resident engineer, and the contractor's agent is Mr. M. W. Henty, Assoc. M. Inst. C.E., who succeeded Mr. A. M. Smith in that position in 1908. We are indebted to the engineers and the several contractors for information, and for the use of the plans and photographs from which our illustrations have been prepared.

Fig. 20—CULVERT IN LOCK WALLS

Correction.—In the general plan of the King's Dock, on page 551 of our issue of November 26th, the site of the proposed lock on the north-west side of the existing lock is incorrectly described as "site of proposed dock." The deep water extension and a portion of the area adjoining it should have been shaded to indicate water.

THE GERMAN NAVAL ARCHITECTS.

No. III.*

THE third paper read on the second day was one by Dr. Ing. Fr. Gebers, entitled "Neuere Propellerversuche" (New Propeller Research). It was in the main a description of apparatus used in the Uebigau tank, followed by particulars of results obtained, and by some mathematical deductions from the latter. Dr. Gebers began with a defence of the law of mechanical similarities which had lately been called in question in Germany. He showed that it would hold for the resistance of the ship itself if the water were a perfect fluid, and that under actual conditions it held for the form resistance only, the skin resistance having to be determined separately on the Froude method. With regard to the propeller, he found that the law was still more applicable, the correction required for frictional resistance being of much less importance than in the case of the hull; but he stated that for a practical demonstration of its correctness more experiments would be needed. The Uebigau tank, in which the experiments were conducted, has already been described in the columns of THE ENGINEER—see October 9th, 1908. Its dimensions are 312ft. by 21ft. 4in. by 11ft. 6in. The maximum speed of the towing carriage is somewhat more than 16ft. per second. The work done by the propeller was measured by the help of a propeller dynamometer, made by Fuess, of Steglitz, near Berlin. Runs with the propellers of various dimensions were made at corresponding speeds. At low speeds the experiments were disturbed by the formation of eddies, which suffered air to penetrate down into the water about the propeller. In these cases the law of mechanical similarities ceased to hold. From the results given it is apparent that the efficiency of a propeller rapidly decreases when, with a given number of revolutions, the speed of motion ahead decreases; as, for instance, when the thrust is increased in towing. Taylor's statement that thrust and turning moment vary with the square of the speed was not altogether confirmed. Experiments were likewise made on the speed and direction of the particles of water surrounding a model propeller when turning and when moving ahead respectively. The results obtained were given in tabular form, but, like the propeller experiments, were declared to be still incomplete and more or less of a preliminary character. A comparison of the calculated values with those obtained in actual practice encouraged the hope that, on the resumption of the experiments, sufficient material would be obtained to enable a method for the mathematical treatment of the propeller question to be devised.

* No. II. appeared December 3rd.

The discussion was opened by Herr Helling, of Altona, who did not believe that Newton's law of mechanical similarities would hold in the case of cavitation. Experiment had shown that the latter was comparatively more pronounced in the cases of large propellers than in those of their relatively small-scale models. He did not think that attempts to increase the speed of propellers without undue loss of efficiency would meet with success.

Geheimrat Flamm said that, in his opinion, the Gebers experiments proved that it would be possible, by the aid of scientifically and systematically conducted investigations, to increase the efficiency of the propeller—perhaps with a higher speed of revolution. Above all he directed attention to three phenomena:—

1. The retarding effect of the outermost part of the surface of the propeller blades at a speed at which the slip was equal to zero.

2. The diminution of the speed of the water flowing from the propeller near the boss, which was fully explained by the sleeve-like formation observable in the pictures of his own propeller experiments.

3. The depression of the surface of the water above the propeller, which again proved that the action of the latter was to be looked upon as exercising suction rather than pressure on the water.

Dr. Pröll, of Danzig, and, later in the discussion, Herr Wagner, of Stettin, said that the results of Herr Gebers' experiments agreed with results obtained by themselves, the former with a steam launch and the latter with models.

Dr. Förster, of Hamburg, pointed out that experiments made on propellers alone did not enable conclusions to be formed as to the efficiencies of these when fitted on their vessels.

Dr. Gebers, in his answer, said that he was quite alive to the influence exercised by the after-body of the ship on the propeller; it was necessary, however, to begin with the study of the conditions attaching to the action of the propeller itself. The complication due to the form of the vessel was too great to be taken into account at once. The cavitation phenomena in connection therewith were also quite different from those with the propeller alone, and he had for this reason refrained from drawing definite conclusions with regard to them from the results of the experiments so far made by him. Moreover, when the proceedings were suddenly stopped, he had not yet concluded his investigations in this direction.

The last paper on the list, which was read by Herr Miersch, of Charlottenburg, was entitled Schiffsantrieb, mittels Turbo-pumpen and Strahl-propeller, and dealt with the propulsion of ships by means of turbo-pumps and jet propellers. Herr Miersch entered into a detailed mathematical discussion of the merits and demerits of the screw propeller, in particular in combination with the steam turbine, when it was unable to run at the high speed suitable for efficiency. After showing that the theoretical efficiency of the screw propeller could never reach the value of unity, and that its mechanical efficiency would probably not exceed .7, he passed on to the consideration of the main subject of his paper. He said that the failure of previous attempts to apply jet propellers in combination with centrifugal pumps had been due to imperfections of the latter, which had since been removed, and further to the want of a suitable main engine. The only engines suitable for driving the centrifugal pumps required were the steam turbine and the gas turbine, the former of which at least was now available. The earlier experiments would have given better results if the suction principle had not been neglected.

The illustration given of the jet propeller showed a bell-mouthed tube through which water was to be driven by a centrifugal pump driven by a steam turbine. Round the tube was a somewhat shorter casing of from one and a-half to twice the diameter of the latter. The bell-mouth of the pipe projected into the larger end of another shorter bell-mouthed tube of larger diameter, which might be called the jet-pipe. Between the two pipes there was a considerable clearance space, through which water from without was sucked, much as in an injector. The sectional area of the stream issuing sternwards from the jet-pipe was thus considerably augmented, and passed aft with a considerable reduction of its speed. For going astern, the pipe, the bell-mouth of which was bent outwards and doubled over, was moved aft till it bore against the jet-pipe and did away with the clearance space. At the same time the entrance at the fore end of the pipe was closed and an annular passage opened for the water into the space between it and its casing. At the fore end of this space the water was diverted through a clearance space between pipe and casing, so that it issued in a direction opposite to that of the inflowing current, *i.e.*, in the direction from stern to stem, thus driving the vessel astern.

In general appearance the jet propeller was not unlike a screw propeller deprived of its blades. The smallness of its dimensions enabled it to be placed in the most suitable position in the after body for propulsion, and the case was of such strength that propeller-brackets and such like encumbrances might be dispensed with. When the vessel was moving ahead the water sucked into the jet pipe through the clearance space was diverted forwards so as to meet the sternward current from the

pipe. This looked like a source of loss of energy, but Herr Miersch asserted that such was not the case. The transformation of the energy within a closed space proceeded, he said, entirely without loss. This he declared to be the leading idea in the apparatus. The arrangement of the apparatus was such that the rapid currents produced were for the most part bounded, not by the walls of the pipes, but by water, and this was considered to add materially to the efficiency of the propeller. In going astern it was estimated that sufficient resistance would be developed to stop the vessel in from one to two minutes. With regard to the turbo-pump, Herr Miersch considered that the efficiency of .8, with which it is usually credited, might be much improved upon, and sketched out a design embodying suggestions to this end.

To show the advantages of his system as regards space occupied he gave illustrations of the after end of a twin-screw passenger and cargo vessel with reciprocating engines and screws, and with turbo-pumps and jet propellers respectively, about two-thirds of the engine-room proper being apparently entirely saved in the latter installation.

Provided the jet propeller worked with a better efficiency than the screw, which he expected, Herr Miersch considered that, in view of the advantages of the combined arrangement, it would be sure to come into general use. The decision would have to be left to practical experiment. The advantages of the jet-propeller arrangement were:—Saving of weight and space; abolition of shafting, bearings, and stuffing-boxes; abolition of the circulating and air pumps, and the possibility of using the turbo-pumps to keep down the water in case of collision. The disadvantages were:—The possibility of the suction openings of the propeller becoming choked, and the chance of inaccessible parts of the jet apparatus rusting away. In conclusion, Herr Miersch asked the profession to give unprejudiced consideration to his proposals, and hoped that they might soon be realised in actual practice.

After a short discussion, the proceedings terminated.

THE SMITHFIELD CLUB SHOW.

The engineering exhibits at the Smithfield Club Cattle Show, which was opened last Monday at the Royal Agricultural Hall, Islington, are well up to their usual standard, and all the firms which are generally to be found there are represented, most of them having stands in precisely the same positions as last year. The show is always bright and interesting, for when one tires of viewing machinery there are other fine exhibits to be seen in the form of cattle, ranging very considerably in size and power, and most of them being exceptionally well lagged; there are no "light tractors" in the cattle department.

Marshall, Sons and Co., Limited, of Britannia Ironworks, Gainsborough, have an excellent show of machinery. There is one of the firm's new oil tractors mounted on springs. This is intended for all kinds of road haulage, and it is also adapted for general farm work, such as ploughing, cultivating, hauling mowers, &c., and for driving thrashing machines, chaff cutters, and other farm machinery. Simplicity of construction and low running cost, we are informed, have been the subject of careful consideration. With paraffin at 6d. per gallon, it is claimed that an acre of land can be ploughed at a cost of 3s., and from six to ten acres of land can be ploughed in ten hours. An illustration of a tractor similar to the one exhibited is shown in Fig. 1. A 6 horse-power compound spring-mounted traction engine which is built in accordance with the latest practice, is also on view. Another exhibit on this stand takes the form of a 6 horse-power single-cylinder portable engine. The bottom of the cylinder is planed to fit the boiler, and the latter has a strong flange extending from each end, as well as at the sides, and it is bolted on the shell of the fire-box. The working pressure is 120 lb. per square inch. A large thrashing machine is also exhibited on this stand.

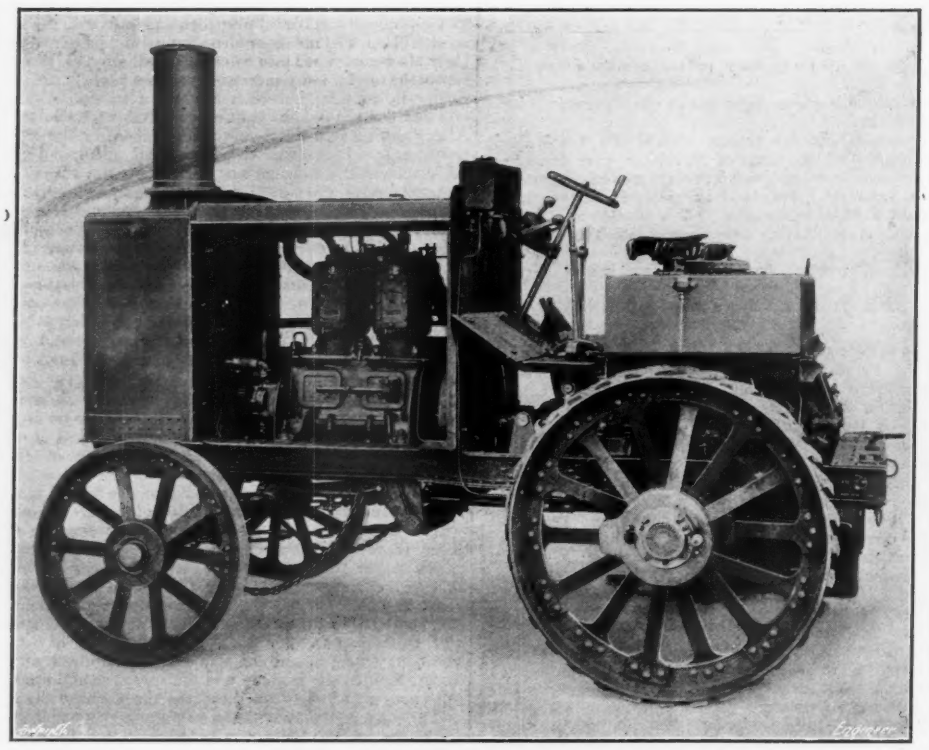


Fig. 1—MARSHALL'S OIL TRACTOR

Ruston, Proctor and Co., Limited, of Lincoln, are also showing some very creditable exhibits, and the 7 horse-power compound steam tractor, shown in Fig. 2, is one of these. It is constructed entirely on modern lines, and the finish is excellent. Among the good features to which attention may be called are—the countershaft is square, thus dispensing with keys or feathers; the steam chest is on top of the cylinder, and one cover serves for both cylinders; the working pressure is 180 lb. per square inch; with the aid of the usual starting valve both cylinders can be supplied with high-pressure steam, thus giving greater power when starting; and the engine has a large coal bunker and water tank. All motions are of extra deep section, and they are case-hardened. The travelling wheels are provided with large "tee" ended spokes of heavy section. On the same stand there is a "Ruston" double-crank thrashing machine. The method of lubricating this machine is a feature to which particular attention is directed, the firm's new ring oiler bearings being fitted to all outside shafts and spindles. The machine has an iron drum of improved pattern with extended face-plates. An improved barley awner is fitted, in addition to the usual "creeper," on the back end of the machine. In addition, the firm is exhibiting a 4ft. clover huller, a five-knife power chaff-cutting machine, and a 2½ horse-power oil engine.

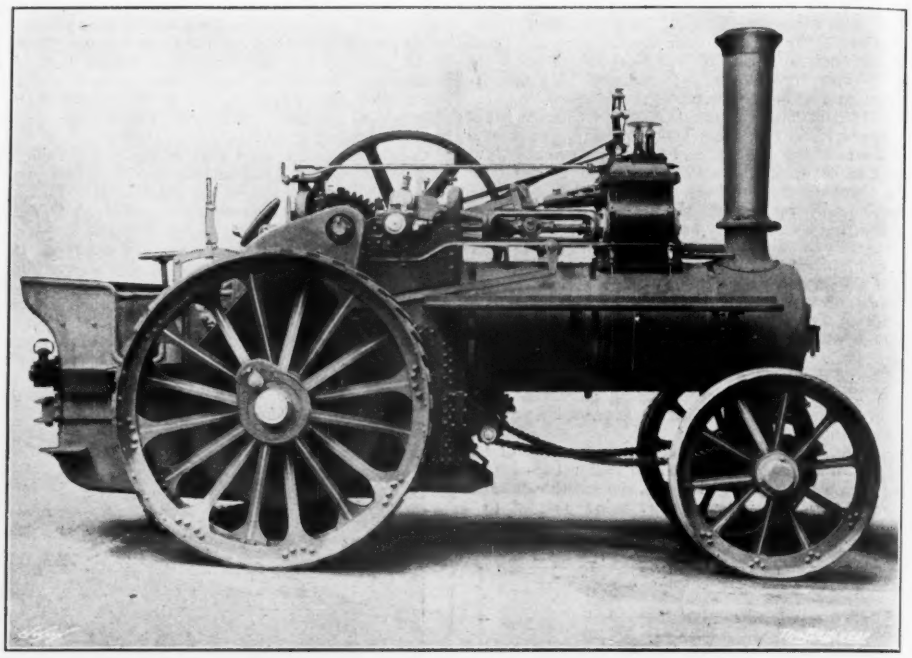


Fig. 2—RUSTON-PROCTOR'S 7-H.P. COMPOUND STEAM TRACTOR

John Fowler and Co., of Leeds, are exhibiting many things. There is a compound ploughing engine for working on the double system of steam cultivation. It is fitted with a governor and equilibrium throttle valve, so that the engine may be used for thrashing, sawing, pumping, &c. The winding drum carries 500 yards of steel rope, which is coiled on the drum by means of the firm's patented self-acting gear and adjustable rope guide pulleys. The firm's improved double-crank compound road locomotives are also shown. There is a 55 horse-power engine, also a compound spring-mounted tractor. Its weight empty is under 5 tons, and can be registered and used under the regulations of the Light Locomotives Act. The tractor is fitted with a recently patented safety clutch gear, the two speeds being controlled with one handle. When one speed is put into gear, the other gear is automatically locked, and the mechanism renders it impossible for the two speed gears to come into operation at the same time. The firm is also showing working models of various steam cultivating implements and samples of wire ropes for steam cultivation, &c.

The exhibits on the large stand of Clayton and Shuttleworth, Limited, of Lincoln, include a fine 6 horse-power single-cylinder portable steam engine, a compound steam motor tractor, an improved finishing thrashing machine, and two agricultural engines. The portable engine is of the makers' standard pattern, the outstanding features claimed for it being simplicity and economy. Little change has been made in the design of the firm's compound steam motor tractor, and it would not be easy to suggest where improvements could be made. The finishing thrashing machine is entirely in accordance with modern design, having self-oiling bearings throughout, and the firm's latest type of barley awner. The spindle of the barley awner now passes through the machine, and is fitted with a pulley at one end. From this a belt drives the small blower. This is a decided advantage over the arrangement in which the blower was driven from the riddle crank. Another improvement is that the spindle is now provided with three bearings instead of two. A much simpler method of adjusting the barley awner has also been adopted than hitherto. As regards the new features of the firm's traction engines, mention should be made of the fact that the cylinders are now fitted to a pressed steel seating riveted to the boiler instead of being mounted on the usual cast iron saddle. With this arrangement the steam enters the cylinders direct from the boiler, thereby ensuring dryness and freedom from priming. In the compound engines the high and low-pressure steam chest covers are placed at the sides instead of being above the cylinders; this arrangement, it is claimed, rendering the valves more accessible. The pumps are of the new geared type, in which the speed of the plunger is greatly reduced, with a consequent diminution in the wear and tear. The first and second motion gear wheels are fitted between the hornplates, although the cylinders are constructed with the steam chests at the sides. This has been attained by a special arrangement of the valve gear. Usually where external steam chests are employed the first and second gear is placed outside the hornplates and the engine made wider to suit these conditions.

On the stand of Richard Garrett and Sons, Limited, of Leiston, there is an exceptionally interesting exhibit, which takes the form of a single-cylinder superheated steam traction engine for driving threshers or other machinery, as well as for continuous road haulage. This is an entirely new departure in the direction of traction engine design, and the exhibit receives more than an ordinary amount of attention. As the result of many trials, we are informed, the engine has proved to be considerably more economical than those working with saturated steam. The fuel and water consumptions are

said to be from 30 to 40 per cent. lower than those obtainable with the ordinary type of single-cylinder traction engine having only one cylinder. We are also informed that it shows an improvement in fuel and water consumption amounting to as much as 10 to 15 per cent. as compared with a compound traction engine using saturated steam. The coil of pipe which constitutes the superheater is placed in a chamber above the ordinary smoke-box, and out of the way of the boiler tubes. Another special feature about this engine is that it has a balanced piston valve instead of the usual flat D valve. The engine is also fitted with the firm's corrugated fire-box. On the same stand there is also a seven horse-power single-cylinder traction engine of the firm's usual type, and intended for general purposes; also a 5-ton Garrett compound steam motor tractor, an "Express" type road locomotive, and one of the firm's 4ft. 6in. heavy type patented finishing threshers.

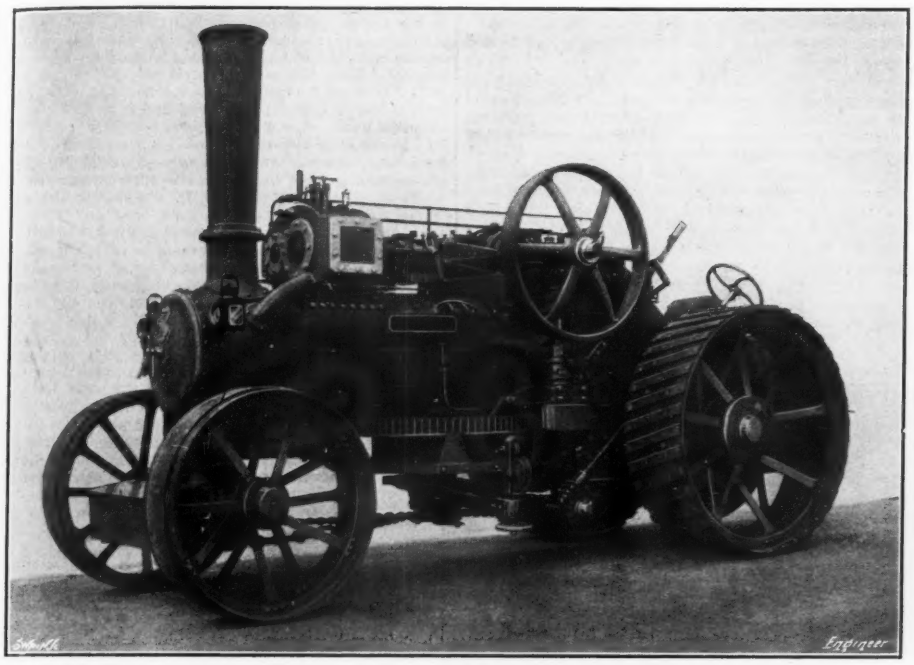


Fig. 3—AVELING AND PORTER'S PLOUGHING ENGINE

Aveling and Porter, Limited, of Rochester, Kent, are exhibiting a road locomotive, a motor tractor, and a ploughing engine. The latter, which is shown in Fig. 3, has several features worthy of attention. In the first place, it will be observed that it has a longer smoke-box than is generally fitted to engines of this kind. Several advantages, we are informed, have been gained by lengthening the smoke-box. A better draught is said to have resulted from the design, and it has been found that steam can be raised more rapidly than is possible with the engines having shorter smoke-boxes. Less fuel consumption is also said to have resulted, and lastly, the smoke-box never gets hot. It will be seen that in this engine the steam chest is at the side of the cylinders. Another special feature is that the guide pulley of the winding drum can be turned through almost any angle, thus enabling the plough to be pulled from nearly any position without moving the engine, which is an advantage in an awkwardly shaped field. A middle bearing is employed for supporting the crank shaft. The engine is rated at eight nominal horse-power. The clutch for starting and stopping the winding drum, it will be observed, is mounted on a vertical shaft driven by bevel gearing at the top.

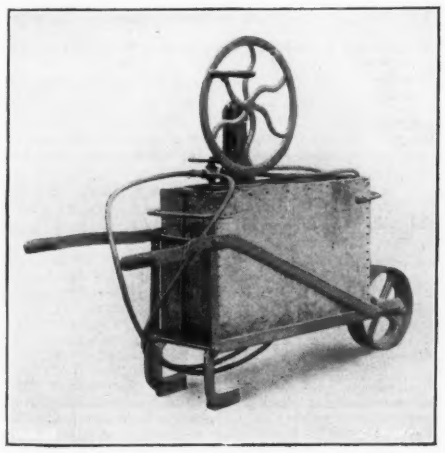


Fig. 4—SPRAYING MACHINE

James B. Petter and Sons, Limited, of Nautilus Works, Yeovil, are, as usual, exhibiting their standard oil engines and pumps. It will be remembered that this firm's oil engines belong to that class in which there is no lamp or external flame except for a few minutes when starting. The "Handy-man" engines, as they are called, work on the well-known four-cycle or Otto principle, and consume ordinary paraffin or lamp oil.

Ransomes, Sims and Jefferies, Limited, of Ipswich, are showing an extensive display of agricultural machinery, including traction, portable, and vertical engines. Also a thrashing machine, ploughs, a swath turner, horse rakes, cultivators, &c. Crossley Brothers, Limited, of Openshaw, Manchester, are also well represented, and are showing some excellent oil and gas engines, and a suction gas plant, all of which are admirably suited for agricultural service. Another firm exhibiting a gas engine and producer is that of Davey, Paxman and Co., Limited, of Colchester, and on the same stand some well finished traction engines are to be found. A good selection of oil engines are also on view on the stand of Richard Hornsby and Sons, Limited, of Grantham, who also exhibit a blinder, a straw trusser, mowers, ploughs, and a drill. The firm of Capel and Co., of 168, Dalston-lane, N.E., are represented this year, their exhibits taking the form of petrol engines suitable for agricultural and general purposes. An oil engine, a windmill, and some pumps constitute the exhibits of the firm of Ockenden Limited, of 126, Southwark-street, S.E. Pitler and Co., of 22, Bush-lane, E.C., have a well-arranged stand on which are to be found petrol engines, a horse rake, pumps, a sprayer, and other agricultural implements. Fairbanks and Co., of 78-80, City-road, E.C., are showing portable horizontal and vertical stationary engines, pumping plant, and an oil engine. Petrol and oil engines, a pump, lifting jacks, &c., are to be found on the stand of Fairbanks, Morse and Co., of 87, Southwark-street, S.E. The Campbell Gas Engine Company, Limited, of Kingston, Halifax, is well represented this year, the exhibits comprising oil engines, gas engines, and a suction gas plant.

Alfred Dodman and Co., Limited, of King's Lynn, are showing vertical and horizontal engines, a boiler, and a spraying machine. The latter, which is illustrated in Fig. 4, is useful not only to the agriculturist but to others also, for it is capable of dealing with many kinds of liquids. For example, it can be used for spraying paint for covering walls, &c. It will be observed that the machine is operated by means of a hand wheel instead of a straight lever, as is more customary. It will also be seen that the pump is driven by means of a small crank. The pump works at a high pressure, and it is capable of supplying the liquid to four jets at once. The pump is fitted with a special relief valve, so that in the event of the operator continuing to turn the hand wheel while the jets are shut off the relief valve opens and the liquid is simply returned to the tank from which it was originally pumped. Hollow gun-metal ball valves are used in pumps which are very light. A strainer is provided to prevent any foreign matter finding its way into the pump. Two kinds of nozzles are provided, one set giving extremely fine jets, whilst the other set is suitable for use with thick liquids, such as lime, &c. An efficient agitator is provided inside the tank, by means of which the liquid is constantly kept in motion. The pump can easily be removed from the tank.

Fielding and Platt, Limited, of 73A, Queen Victoria-street, E.C., are showing an oil engine, a gas engine, and a gas producing plant. On the stand of Brown and May, Limited, of North Wilts Foundry, Devizes, Wilts, there is a steam tractor, also a thrashing machine and a portable engine. A special feature about the thrashing machine is that it has three fans. The exhibits of Blackstone and Co., of Stamford, include portable and stationary oil engines, swath turners, a horse rake, turnip cutters, &c. The firm of William Allchin, Limited, of Globe Works, Nottingham, is showing a fine traction engine, provided with all the latest improvements. A traction engine, a steam plough, a ploughing engine, and some pumps are exhibited by the firm of J. and H. McLaren, of Midland Engine Works, Leeds. A steam tractor is being shown by Savage Brothers, Limited, of St. Nicholas Ironworks, King's Lynn. W. H. Wilcox and Co., of 23 36, Southwark-street, S.E., have a good display of machine belting, hose, and other goods needed by machinery users. Weighbridges, weighing machines, scales, &c., are to be found on the stand of W. and T. Avery, Limited, of 14-17, Cow Cross-street, E.C. Cultivators, windmills, and harrows are among the exhibits of the Shelby Manufacturing Company, of Rye Works, Hanover-street, Peckham.

VICTORIAN RAILWAYS.

A RECORD result is shown in the working of the Victorian railways for the year ended 30th June last, a surplus of £235,043 being shown after meeting working expenses, interest on loans, gratuities and pensions, which has never before been achieved. The revenue in goods traffic increased by 13.52 per cent. over that of the previous year, which is practically all attributable to the favourable grain harvest. The dining car service which was started during the year on the Sydney and Adelaide express trains and on the Mildura line was a new source of revenue. Working expenses increased £123,542, which was mainly due to additional train mileage required to deal with the larger goods traffic, to advances in salaries and wages, and to the payment of £90,863 into the Railway Accident and Fire Insurance Fund, as compared with £15,667 in the previous year.

A different system is adopted with regard to the disposal of the surplus revenue on the Victorian railways to what operates in the other States. It has been the custom to pay the surplus revenue into the Railways Additions and Improvements Fund and the Railways Interest Reserve Fund, but for this year it has been decided to suspend the operation of this Act, and for the State Treasurer to allow the Railway Commissioners' interest at the rate of 3½ per cent. per annum on the amount so credited until it is made good to the two funds mentioned.

A contract was entered into with Messrs. R. W. Cameron and Co. on account of the Lorain Steel Company for the supply of 12,257 tons of 80 lb. and 1571 tons of 100 lb. steel rails, equal to about 108 miles of track at £5 7s. 9d. per ton, exclusive of duty, delivered into trucks at Melbourne.

Result of the Working Compared with the Previous Year.

		Year ended June, 1908.	Year ended June, 1909.
Average miles open		3,396	3,357
Total miles open		3,396	3,410
Cost of construction	£	41,928,167	42,485,323
Average cost per mile open	£	12,344	12,459
Gross revenue	£	3,873,368	4,178,124
Working expenses	£	2,285,857	2,409,439
*Net revenue	£	1,587,471	1,768,685
Special expenditure and charges	£	47,058	—
Interest charges and expenses	£	1,483,857	1,430,093
Pensions and gratuities	£	—	105,415
Surplus	£	52,681	235,043
Train miles		10,383,418	11,230,578
Passengers carried, number		74,907,425	81,020,620
Goods and live stock, tons		3,754,361	4,166,786
Gross earnings per train mile		7s. 5·57d.	7s. 4·81d.
Working expenses per train mile		4s. 4.84d.	4s. 3.22d.
Locomotives, tractive power, lb.		—	8,150,048
Carriage stock, floor-area, sq. ft.		—	345.164
Truck stock, carrying capacity, tons		—	116,110

* Exclusive of St. Kilda and Brighton Electric Street Railway.

THE PHYSICAL SOCIETY'S ANNUAL EXHIBITION.—This exhibition, which is to be held on Tuesday the 14th inst., will differ from that of previous years in that it will be open in both the afternoon—from 3 to 6 p.m.—and in the evening—from 7 to 10 p.m. Short discourses will also be delivered at 4 and 8 p.m. by Professor C. V. Boys, F.R.S., on "Soap Bubbles," and at 9 p.m. by Professor S. P. Thompson, F.R.S., on "Combinations of Mica and Selenite Crystals." The following firms will be exhibiting:—Bausch and Lomb Optical Company; British Radio-Telegraph and Telephone Company, Limited; Cambridge Scientific Instrument Company; Casella and Co; A. C. Cossor, Limited; H. W. Cox and Co.; G. Cussons, Limited; the *Daily Mirror*; J. H. Dallmeyer, Limited; Elliott Brothers; Everett, Edgcumbo and Co.; Gallenkamp and Co.; Gambrell Brothers; F. Harrison Glew; J. J. Griffin and Sons; Hicks and Co.; A. Hilger, Limited; India-rubber, Gutta-percha, and Telegraph Works, Limited; Isenthal and Co.; Marconi's Wireless Telegraph Company; Leslie Miller; Muirhead and Co.; Nalder Brothers and Co.; Nalder Brothers and Thompson; Negretti and Zambra; Newton and Co.; R. W. Paul; Pitkin and Co.; the Reason Manufacturing Company; Ross, Limited; Siemens Brothers and Co., Limited; Snell and Tinsley; Strange and Graham; Synchronome Company; Weston Electrical Instrument Company; Carl Zeiss, Limited. We understand that invitations have been given to the Institution of Electrical Engineers, the Faraday Society, the Optical Society, and the Röntgen Society. Admission in all cases will be by ticket only, and therefore members of the societies just mentioned—including also the Physical Society—desiring to attend the exhibition should apply to the Secretary of the Society to which they belong.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE.—The annual dinner of the members of this body was held in the Grosvenor Restaurant, Glasgow, on December 4th, Mr. P. M. Cunningham presiding over a company of three hundred. Among those present were:—Mr. C. R. Askwith, K.C., Labour and Statistical Department of the Board of Trade; Rear-Admiral F. B. Adair; Mr. George Beilby, LL.D., Chairman of Governors of Glasgow and West of Scotland Technical College; Professor Magnus Maclean, Engineer-Commander G. A. Haggarty, R.N.; Mr. G. C. Lloyd, Secretary Iron and Steel Institute. Rear-Admiral Adair, in responding for "The Navy," remarked that within the last twelve or fifteen years there had grown up a naval rival to us in the North Sea such as we had not had before our eyes since the old French wars. It was a rivalry we did not fear, but it was one for which we had the utmost respect, and it was just such a stimulus as the Navy wanted. If our opponents were seeking to make a reputation, it was our Navy's ambition to pass on to successors as glorious a record as had been inherited. Dr. Beilby, in proposing "The West of Scotland Iron and Steel Institute," referred to the need for industries being better organised, more scientific, and more complete in regard to technical knowledge and skill. The British iron and steel industry was no longer the iron and steel industry of the world. New nations were coming into the arena of industrial competition, and even in the East they had Japan, India, and China all shaping towards the making of great industrial countries. Competition was now world-wide, and that could only be properly met by putting ourselves in the best possible position as to equipment, education, and scientific knowledge. Why should not the University, the Technical College, and the Iron and Steel Institute unite as one in an effort to make Glasgow renowned all over the world for its achievements in metallurgical science? Let a great strong school of metallurgy be established to which men from all parts of the world would flock.

OBITUARY.

HILARY BAUERMAN.

It is with deep regret that we have to announce the death of Professor Hilary Bauerman, which took place at his house in Balham on Sunday morning, the 5th inst. Professor Bauerman had been seriously ill for about ten weeks, and the immediate cause of his death, which took place peacefully, was heart failure.

Professor Bauerman was, apart from his other qualifications, which were not few, among the foremost authorities on mineralogy and metallurgy of his time. His whole life was spent in the study of these sciences, and his knowledge and abilities in this direction were widely acknowledged, his services being frequently requisitioned when abstruse points came up for decision. His professional career began in 1851, when he entered the Royal School of Mines, which he left in 1853 in order to proceed to the Freiberg Mining Academy, where he stayed until 1856. Before he left, that is to say, in the year 1855, he was appointed assistant geologist to the Geological Survey of Great Britain, which post he held until 1858, when he was employed as geologist to the North American Boundary Commission. This work lasted some five years, and terminated in 1863. Between the years 1863 and 1888 he was busily engaged in surveys and explorations abroad, and as showing how wide was his field of activity, we may say that the countries which claimed his attention included, besides Great Britain, Arabia, the Red Sea and the Gulf of Aden; Arizona; Asia Minor; Bengal Beraro and Kumaon; Brazil; North and South Carolina, Colorado, Granada; Lapland; Mexico; Michigan; Missouri; Peru; Portugal; Savoy and Sweden. At different times during his life he had practically visited the whole of Europe, including even the Eastern parts of Russia. His experience was consequently exceptional, and might almost be called world-wide, and being gifted with a wonderful memory, which remained to him unimpaired until his end, his fund of information concerning the subjects which he had made particularly his own was inexhaustible.

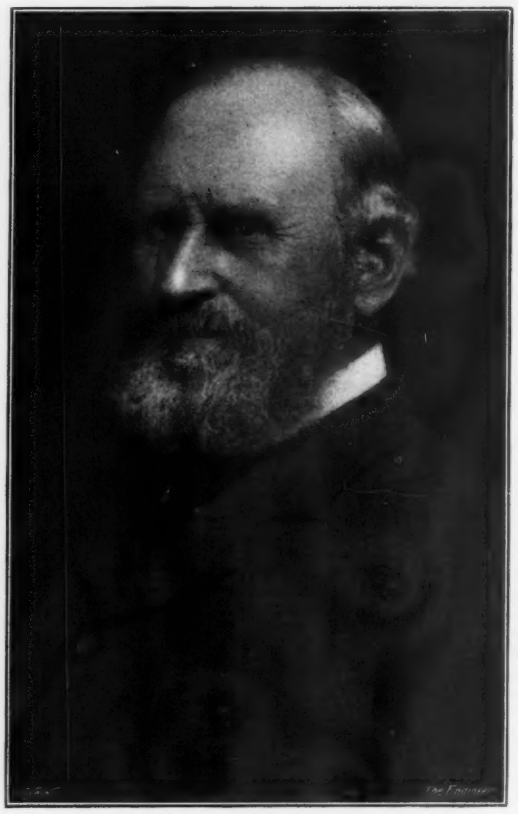
His whole life, however, was not devoted to survey. Much of it was taken up in teaching other people what he had learnt with so much assiduity. As a teacher, and especially when teaching individually, his influence was great and far reaching. As early as 1883 he was appointed lecturer on metallurgy at Firth College, Sheffield. Between the years 1874-1879 he was joint Examiner in Mining and Mineralogy for the Science and Art Department. His last official appointment was as Professor of Metallurgy to the Ordnance College, Woolwich, from which he retired in 1906 after nearly twenty years' service. An incident which occurred during this period is worthy of recording as being typical of the man. It occurred during a lecture at which a number of labelled samples of minerals was being shown and discussed. It happened that a student made his way into the lecture theatre before the lecture, and removing one of the labels, substituted for it one bearing the inscription "Bauermanite." The Professor during the course of his lecture referred to the various samples, beginning thus, "This is a piece of gneiss, this is a piece of granite, this is a piece of quartz," and so on—then taking up the "Bauermanite" sample, and without a change of countenance, "this is a piece of —— impertinence,"—and without hesitating a moment continued his reference to the remaining minerals.

So greatly were his attainments appreciated that he was made a juror in the Mining and Metallurgical departments of practically every exhibition of recent years, beginning with that of Paris in 1878 and continuing with the Inventions and Antwerp Exhibitions of 1884, that of Chicago in 1893, of Paris in 1900, of St. Louis in 1904, and lastly of the Franco-British Exhibition last year.

His literary ability was of no mean order, and his work in this direction was extensive. In addition to many important papers read before learned and technical societies, his name is perhaps best known in connection with his classical book on the "Metallurgy of Iron," and with the treatise on "Metallurgy," by Phillips and Bauerman. He was also the author of "Descriptive Mineralogy," and of "Systematic Mineralogy." For many years he was a valued contributor to the columns of THE ENGINEER, and we may state that at 6 o'clock on the morning of the day before his death he dictated a review of the last issue of the "Annuaire of the Bureau des Longitudes." He had, at his own request, reviewed preceding issues of this work for us for a number of years. His knowledge was by no means confined to his own particular subjects, and we frequently received contributions from his pen on matters widely different from mining or metals. Indeed, his interests extended over many sciences and arts other than those with which his name is most associated. For instance, he was universally recognised as one of the highest authorities on crystallography, a subject which with him had become an absorbing hobby. He found no greater delight, and was rarely more delightful himself than when with no more appliances than an old envelope picked out of the waste-paper basket he would, simply by deft folding—accompanied always by a constant puffing and blowing, and many a joyul chuckle—develop some extraordinary figure in solid geometry. There are, we understand, amongst his remains a great number of these paper forms, and it has been suggested with a good deal of reason that they should be collected and given to some museum. That they were all made from flat paper by simple folding and cutting is a fact that always excites interest and surprise, but at the same time they are of high educational value.

Professor Bauerman belonged to many societies and institutions at home and abroad. Of these he was honorary member of three, namely, the Chemical, Metallurgical and Mining Society of South Africa; of the Institute of Mining and Metallurgy; and of the Iron and Steel Institute. He was an associate member of the Institution of Civil Engineers, a fellow of the Geological Society, and an associate of the Royal School of Mines. In 1897 he was awarded the Howard Prize of the Institution of Civil Engineers, and in 1906 received the gold medal of the Institute of Mining and Metallurgy.

As a man he was of a most charming disposition, and was much loved and honoured by a wide circle of friends and admirers. He was of a strongly artistic temperament—a trait of his character not generally known—and was a great admirer and excellent judge of good pictures. His sense of humour was keen, and he was a most genial companion on excursions—altogether a man to be desired. In his enjoyments he was unlike the majority of men. Hardly anything pleased him, for instance, more than a mathematical or geometrical problem, and he was a voracious and comprehensive reader. He had a passion for books; indeed, on those days on which he might be expected to pay us a visit we were careful to hide any valued volume, lest he should take a fancy to it and run off with it. He was perfect master of five or six languages.



HILARY BAUERMAN

GEORGE WILLIAM HAWKSLEY.

THE death is announced of Mr. George William Hawksley, founder of the firm of Messrs. Hawksley, Wild and Co., Brightside Boiler Works, Sheffield. Mr. Hawksley was apprenticed to his uncle, a millwright at Owlerton, Sheffield, and subsequently went to the Hyde Boiler Works of Mr. Daniel Adamson. While engaged at Hyde he met Mr. Matthew Wild, who was then foreman in the boiler yard. In 1860 these two gentlemen started the business at Sheffield, which developed into one of the most important boiler-making establishments in the country. At a later period Mr. Hawksley purchased two extensive dye works at Wakefield and Halifax. He was in his 74th year.

HOSPITAL WARMING AND LIGHTING.

IN one of the sections of the Electrical Congress at Marseilles last year some interesting papers were read, followed by lively discussions, upon the lighting of and supply of heat for all purposes, including cooking and baths, to large buildings. We have received a paper on this subject published two months ago in the journal *Gesundheits-Ingenieur*, or *Sanitary Engineer*, of Berlin. It makes a comparison of the costs of three systems for a hospital of 800 beds. The estimates are for general warming, baths, cooking, washing and lighting and workshop power. In each case there is centrifugal force-pump circulation of hot water.

In the first there are two condensing 100 horse-power cylinder steam engines, two direct-coupled 60-kilowatt dynamos, an accumulator battery, two boilers of 70 square metres heating surface each, and 2200 electric glow lamps of 16 candle-power. This installation costs £8550 in capital outlay, the interest and amortisation of which is reckoned at £831, which, with other expenditure, makes the annual expense £1306.

The second estimate is for two steam turbines with direct-coupled dynamos 60 kilowatts each, battery, four boilers of 60 square metres heating surface each, and the same electric lighting equipment. The capital cost sums up to £7550, on which the interest and amortisation is taken as £753. With working costs the total yearly cost comes to £1308, practically identical with that of the first scheme.

The third estimate is for gas lighting and gas engines for the mechanical power required, the general warming and heating being effected by special steam boilers. Two gas engines of 16 horse-power each, four boilers of 50 square metres heating surface each, and 600 Auer lamps of 60 candle-power each are supplied. Here the capital cost is only £1750, on which £273 is assumed for interest and amortisation. The working costs of the gas systems alone are found to be £780; but, on the other hand, other working costs, including extra pumps for the supply of hot water to various parts of the building, are £468. Thus the total costs per year are £1521. This is 16.3 per cent. greater than either of the other two schemes. This result illustrates the fact that in engineering the smaller capital cost often means the greater total annual expense. The paper shows the general arrangements only by diagram, and the merits of such designs cannot be judged except upon information as to details. Although we agree that the main conclusion is correct in general direction, we must admit that the arithmetic of the estimates presented is not convincing. We are no sticklers for arithmetical exactitude, and especially in this class of work it is quite impossible to calculate accurately the various quantities required. But when it comes to an emphatic declaration that $3\frac{1}{3} \times 36 = 120$, we do not hesitate to stand by the opinion that a 5 per cent. error in arithmetic is worth avoiding in a calculation in which three-figure data are assumed, such as 13.8 kilos. steam per horse-power hour. Again, we show above an 16.3 per cent. difference in annual cost, whereas this light-footed reckoner gaily states the same difference as 30 per cent. The error in this last is 84 per cent. Nevertheless, the author is at pains to consider with some minuteness the difference between the two above-mentioned figures, £1306 and £1308, and to explain that it is "practically counterbalanced" by the less costly foundation needed by the turbines and by the greater heat wastes in the reciprocating engines; two variations which he has left out of account and which we may assure him would amount to much more than £2 per year. His "interest and amortisation" calculations are also somewhat primitive. He keeps to the pleasing factor of 10 per cent. for *all* items, engines, turbines, dynamos, batteries, gas and electric lamps, pipage, pumps, tanks, reheaters, &c. &c., except buildings, which he takes at 7 per cent. All these items are calculated separately and with great care, but all at 10 per cent. In scheme II. and III. he omits all wages, while inserting £60 for this item in I.; and yet both items and totals are run out to 10s.

We ought to say that these estimates are for low steam pressure, only 6 lb. per square inch above atmosphere, with surface tube condensers. The fuel is taken as hard coal at 20s. per ton for I.; coke at 25s. per ton for II. and III. In I., 22 lb. of steam are allowed per horse-power hour, and 30 lb in II. The summer lighting is assumed to use $\frac{3}{10}$ the kilowatt-hours of energy required for the winter period of 200 days.

AMERICAN RAILWAY ACCIDENTS.

DURING the quarter ending June 30th last, according to the Bulletin of the Interstate Commerce Commission, there were fewer people killed in train accidents than in any previous quarter since the Bulletins were commenced eight years ago.

The figures are as follows, and comparison may be made with the corresponding quarters of the years 1907 and 1908, if THE ENGINEER of October 23rd, 1908, be referred to:—

	Passengers. Killed.	Injured.	Trainmen. Killed.	Injured.
Collisions	1	355	17	272
Derailments	6	715	49	315
Miscellaneous train accidents, including boiler explosions	—	16	4	201
Total train accidents	7	1085	70	788
Coupling or uncoupling	—	—	16	277
Other work about trains	—	—	14	2243
In contact with overhead or side structures	—	6	15	191
Falling off engines or cars, or in getting on or off	27	787	54	1255
Other causes	10	8:8	35	207
Total other than train accidents	37	1651	135	4173

The same Bulletin gives the advance figures for the fiscal year which ends on June 30th, 1909. The corresponding figures for the years 1905, 1906, 1907, and 1908 may be found in our issue of June 18th last. The figures for 1909 are:—

	Killed.	Injured.
Passengers—		
In train accidents	131	5,865
Other causes	204	6,251
Total	335	12,116
Servants—		
In train accidents	520	4,877
In coupling accidents	161	2,353
Overhead obstructions, &c.	75	1,229
Falling from cars, &c.	481	10,259
Other causes	1218	33,086
Total	2456	51,804
Total passengers and servants	2791	63,920

RAILWAY MATTERS.

CONSIDERABLE importance is attached in Ottawa to the opening of the Canadian Northern Quebec Railway, over which the first train between Quebec and Ottawa ran on Monday last.

At a number of its more important stations, such as Howrah, Asansol, Moghal Sarai, Sutna, Allahabad, Jubbulpore, and Delhi, the East Indian Railway is erecting new turntables with a larger diameter to suit the heavier types of locomotives recently put to work. These turntables are to be 60ft. in diameter.

ACCORDING to the *Railroad Age Gazette*, the Mexican Railway, which recently equipped thirty of its locomotives to burn oil, has been unable to get an adequate supply of this fuel, and has had eighteen engines reconverted into coal burners. The oil company which failed to carry out its contract, it is reported, bears the expense of the change.

ACCORDING to the *Industrial World*, Pittsburgh, the bids recently received for the supply of ten locomotives for the Argentine Northern Railway were as follows:—Henschel and Sons, Germany, 9860 dols. per engine; the American Locomotive Company, 9742 dols. per engine; Havre Forges and Foundry Company, 9950 dols. per engine; North British Locomotive Company, 10,104 dols. per engine; Baldwin Locomotive Works, Philadelphia, 10,365 dols. per engine.

AT a meeting of the North-Eastern railwaymen of all grades held at Middlesbrough on the 5th inst., to consider the concessions granted to the workmen under the recent award of Sir James Woodhouse, respecting wages and working conditions, general dissatisfaction was expressed with the award, and a resolution was carried by 155 votes to 20 declaring that the terms of the award were an insult to the intelligence of the men and a mockery to their labour, and that a conference be called to enforce a standing day of eight hours for all grades.

THE railway which is being built round the Hangchow Bay to Ningpo is wholly a private Chinese enterprise. On the first 37 miles from Shanghai south-west, which were opened last May, there are ten stations and forty-eight bridges. The country is nearly level, and the numerous rivers to be crossed form the chief obstacle. The rails came from the works near Hankow, the sleepers from Korea, the rolling stock mostly from America, with one of the four locomotives from Germany. The cost of the completed part was about £8100 per mile.

THE work of extending the electric zone of the New York Central Railroad as far as North White Plains is proceeding quite rapidly, and it is expected that by the first day of next year it will be in full operation. The temporary terminus at Wakefield, where steam and electric locomotives are interchanged, will then be abandoned. The new sub-station is being erected at Tuckahoe and another one at White Plains. Each will be equipped with three 1000-kilowatt rotary converters and nine single-phase transformers of 375 kilowatts capacity each.

THE question of sleepers is receiving some attention in India just at present. The Oudh and Rohilkhand State Railway is experimenting with some Californian red wood sleepers, supplied by a San Francisco company. These sleepers measure 9ft. 6in. by 10in. by 5in. It is difficult to understand why it should be necessary to go so far for the timber. Some of the Burmese woods—if nothing nearer could be obtained—would provide excellent material. Indeed, the Burma Railway Company has just placed an order for 100,000 sleepers made of Burmese Pynkado timber.

THE Pennsylvania tunnel system from Harrison, N.J., to New York City and Long Island was, says the *Engineering News*, traversed by the first official train on November 18th. President McCrea, of the Pennsylvania Railroad, Vice-president Rea, and a number of other officials and guests made the trip. As the electric equipment is not ready, a steam locomotive had to be used. The tunnels themselves are completed, but work is still in progress on the New York terminus and the Long Island yard, and the electric line equipment has yet to be placed. The company has stated recently that the whole system will be opened to traffic by June, 1910.

THE Battle River Viaduct of the Grand Trunk Pacific Railway, 675½ miles west of Winnipeg, completed in December, 1908, is a steel-plate girder viaduct 2772ft. long between abutments nd 184ft. high from base of rail to low water, or about 139ft. average height above ground. It comprises a 150ft. deck truss span crossing the main part of the river channel, one 70ft. plate girder span and fifty-one 50ft. plate girder spans, resting on twenty-six steel towers. Thus the tower spans are of equal length with the intermediate spans, *i.e.*, 50ft. The substructure is of concrete, the two river piers and most of the land footings being founded on piles.

NOTWITHSTANDING the general depression characteristic of the year, says a consular report from France, the gross earnings of the six great French railways companies amounted to £65,480,000, compared with £64,280,000 in 1907. Among the several companies the largest amount fell to the Paris, Lyons and Mediterranean, with a length of line of 5962 miles, its gross receipts being £20,544,000; next in order was the Orleans Railway, with 4614 miles of line and receipts £11,033,000. The third place was occupied by the Northern, whose receipts amounted to £10,969,000 on 2356 miles. On the Eastern Railway, with 3128 miles, the earnings were £9,236,000. The Western Railway, with 3690 miles, came fifth with £8,711,000, while the Southern Railway realised £5,025,000 with 2156 miles of lines.

INSTEAD of one southern division of the Midland Railway there will in future be a southern and western division, and the directors have appointed Mr. Harry Powell Miles and Mr. Frank H. Frere respectively to have charge of these. Mr. Miles's most important work has been done as resident engineer in charge of the construction of the southern section of the New Mills to Heaton Mersey line, which includes the Disley tunnel, 2½ miles in length; the West Riding lines between Royston and Thornhill, and the Huddersfield Railway. Mr. Frere was connected with the Liverpool Overhead Railway and the Great Central Railway extension to London, which included the Catesby tunnel. He was appointed resident engineer on the Midland Railway in 1899, and had charge of the widening of that company's system from Trent Station up the Erewash Valley to Pye Bridge, a length of about 14 miles, of the reconstruction of the viaduct over the river Trent near to Trent Station, and of the remodelling and rebuilding of Nottingham Station, a work of considerable magnitude.

COMMENTING on a recent discussion by the New York Railway Club on surprise and efficiency tests, an American contemporary remarks that even the best of automatic signals cannot prevent collisions. It is necessary to take account of the train crew, as is well shown by the statistics published by the Interstate Commerce Commission. In these it was seen that out of the 152 preventable collisions and derailments during two years, 21 cases were due to negligence on the part of drivers to observe signals. It must be conceded, therefore, continues our contemporary, that the best of signal systems, maintained by a good staff of properly paid men, must be supplemented by something which will teach the drivers the importance of observing all rules and signals. Up to the present there has been nothing devised so good as surprise tests, by which the manner in which signals and rules are obeyed is actually examined and recorded. It is a troublesome and exasperating thing to do, but so is the surprise fire drill required once a week on all passenger steamships.

NOTES AND MEMORANDA.

THE telescope which is being installed in the Transvaal Observatory will be the second largest in the British Empire. It will be 35ft. long and have an aperture 26in. in diameter.

LETTERS can now be automatically registered in Berlin by an automatic penny-in-the-slot machine placed in the post-offices, which specially stamps the letters and saves the sender from waiting.

COTTON-SEED and cotton-seed cake have been, we hear, very successfully used for the generation of gas to drive a 30 horse-power gas engine in Nigeria. Six hundredweight of cake is sufficient for nine and a-half hours' running.

WHAT is declared to be the largest and most expensive leather belt ever made for driving purposes has been recently shipped from New York. The belt is 240ft. long, 6ft. wide, three-ply thick, and was constructed at a cost of £1200. To make the belt the hides of 540 steers were required.

IN his opening address, recently delivered before the Leeds local section of the Institution of Electrical Engineers, the President, Mr. W. M. Rogerson, gave some details as to the reduction in the cost of producing electrical energy during recent years For this purpose he compares the data of 1898 with those of 1908. In the former year, taking six typical generating stations, he finds that the average cost per unit sold was 1.85d. In 1908 this figure, taking the same generating stations, was reduced to .78d.

SOME excellent work has recently been carried out by steam navvies on the Panama Canal One navvy working in the Culebra district excavated 45,694 cubic yards of earth in twenty-six working days. A steam navvy working eight days in the Culebra district and eighteen days in the Empire district excavated 16,755 and 26,518 cubic yards respectively—a total of 43,273 cubic yards, the second best record for the month. A third in the Culebra district made a record for one day by excavating 2549 cubic yards of rock and earth.

"FAILURE of a fly-wheel," says our American contemporary, *Power and the Engineer*, "usually begins by the starting of a minute crack on the under surface of the rim at the point of greatest stress, viz., near the ends of the arms adjacent to the rim joint. The cracks gradually deepen until failure occurs, with all its disastrous consequences. These minute cracks are visible to an experienced eye, and careful inspection will aid materially in the prevention of fly-wheel explosions." Our contemporary would seem to have had quite an extensive experience with this class of accident.

AT Haltem, in Westphalia, near the site of the Aluso fortress, erected by Drusus in the year 11 B.C., was recently found a bronze vessel containing a dried black mass, which Professor Kassner has decided to be Roman ink. The mass was found to consist chiefly of soot and tannate of iron. It also contained smaller quantities of ferric oxide, copper oxide, clay, magnesia, gypsum, phosphoric acid, carbonic acid, alkalies, and sand. These ingredients probably represent chiefly accidental impurities which have found their way into the old inkstand, but some of them may be due to the chemical action of the ink on the bronze vessel. The presence of an aromatic substance suggests that the ink was imported from Italy, where the use of perfumed ink was common.

TEN years ago 93 municipalities had electric generating stations, which had cost £5 734,938, while about 70 companies had expended a total capital of £5,261,763 in the same direction. At the end of 1908, which is the latest date up to which the returns are available, there were 541 undertakings, 338 of which belonged to local authorities and 203 to companies or private individuals, the total capital involved being £40.016,300 and £40,722,000 respectively. The capital laid out both by private companies and local authorities had, therefore, increased in about equal proportion. The total lamps connected, equivalent to 8 candle-power, ten years ago, were 4,106.727, and these had increased in 1908 to 35,056,700, while the output in Board of Trade units sold both by companies and municipalities had increased in this time from 60,125,500 to 749,594,200.

THE Indian Meteorological Department collects and distributes current weather information, supplies climatological data, sends storm and flood warnings, and provides time signals. It also aims at ascertaining facts which shall be of practical usefulness in future, and includes the experimental and theoretical examination of the physical processes, alike on the earth or the sun, which determine the weather. It has lately published a meteorological atlas of the Indian seas, which contains a large amount of information valuable to ship captains. It has also recently opened additional stations, which have made it possible for storm warnings to be given with decidedly greater efficiency. On the scientific side, the investigations of the electrical conditions of rainfall undertaken by Dr. Simpson have led to definite and important results. He claims to have discovered the long-sought explanation of thunderstorms, and shown that it lies in the breaking up of drops of rain carried upwards by air currents and the consequent formation of a strong positive charge on the rain with a negative charge in the air.

DISCUSSING the question of the "Water Supply for the Lock Canal at Panama," in a paper read before a recent meeting of the American Society of Civil Engineers, Mr. Julio F. Sorzano sought to prove that during the three or four months' dry season on the Isthmus the various leakages and necessary uses of the canal and its structures would so reduce the water level of the lake at Gatun that it would be impossible to maintain in the canal the 40ft. depth which the present design prescribes. The various causes of loss of water were given as follows:—Surface evaporation, border evaporation, percolation through the bottom and sides of the reservoir, lockage water, normal waste contingent to lockage, water for hydro-electric plants, structure leakage and waste, accident losses; and, finally, a general grouping of miscellaneous losses, such as the needs of the local population and industries, the uses of passing vessels, &c. A computation was given in the paper which proved to the satisfaction of the author that all these leakages and necessary uses would so reduce the water during the dry months that the capacity of the lock canal during that time would be less than would be sufficient for twenty round trips a day, and that at no time after the first month of that dry period would a 40ft. draught be available.

IN a paper read before the Institution of Electrical Engineers by Messrs. G. Wilkinson and R. McCourt reference is made to the economy which can be obtained in the case of arc lamps by substituting large candle-power metallic filament lamps, and also to the fact that the smaller metal lamp may be used as a most effective competitor against the incandescent gas mantle for side-street lighting. From the result of many photometric tests of gas mantles in the roadways it is proved, the authors state, that the average candle-power of a 3ft. incandescent gas mantle does not exceed thirty candles, while with metallic filament lamps 30 candle-power can be obtained for 33 watts. Taking the price per unit for street lighting purposes at 1½d., the price per hour for 30 candle-power is $\frac{66}{1000}$d. Taking the price of gas at 2s. 2½d. per 1000 cubic feet, the cost of 30 candle-power per hour is $\frac{30}{1000}$d., so that for 1000 hours the cost of electricity is 4s. 2d., against 6s. 8d. for gas, but the renewals in the case of electricity (assuming the life of the lamps to be 1000 hours) cost 3s., and for gas (assuming the life of the mantles to be 400 hours) cost 10d., making the totals—electricity, 7s. 2d.; gas, 7s. 4d. These figures do not include the extra cost of labour in the renewals of the gas mantles nor the cost of breakages of chimney glasses, which frequently occur, nor the extra cost of cleaning the gas lanterns.

MISCELLANEA.

AS we go to press, we regret to learn of the death of Mr. Edward Tangye. He was one of the five brothers who founded the well-known firm of Tangyes Limited, Birmingham.

THERE was a rumour on Thursday afternoon, though it lacked official confirmation, that the Thames Ironworks Company, Limited, is to receive an order for building one of the new Dreadnoughts.

THE longest masonry span in the world is said to be the Grafton Bridge, now being completed by the city of Auckland, New Zealand. It is 910ft. long and 40ft. wide, and the middle arch has a span of 320ft., and a roadway elevation of 147ft. above the lowest part of the valley which it crosses.

THE Secretary of the Institution of Mechanical Engineers requests us to announce that applications for grants from the Bryan Donkin Fund, in aid of original research, must be sent to the Council as soon as possible. The first award will be made in February and the amount available will be £27. Conditions of the award can be obtained on application to the Secretary.

ACCORDING to *Indian Engineering*, arrangements are being made in connection with Sind irrigation for immediately throwing a dam across one branch of the Lyari River. The work is to be carried out at an estimated cost of Rs. 141,810, of which the Karachi Port Trust contribute Rs. 65,000 and assume liability for half of the cost of any pitching which may be necessary within five years of completion of the dam.

THE Washington Aqueduct, after forty-six years of of service, is in excellent condition, according to the last annual report of Major Jay J. Morrow, of the United States Corps of Engineers. This aqueduct crosses 26 valleys on 4 bridges and 22 embankments containing culverts. The only signs of deterioration were found, it is reported, in unlined portions of the conduit where a small quantity of rock had fallen from the roof and side walls. It was noted that the mortar in the brick masonry in the lined sections, although inferior to present-day Portland cement, had not been washed out of joints to any great extent. Recent experiments showed that 90,000,000 gallons per day is about the maximum carrying capacity of the aqueduct.

THE depth of water in the middle of the Berlin Stettin Canal will be 3 mm. (9·84ft.), and the breadth at the surface in ordinary soil 33 mm. (108·24ft.). In soft, peaty ground it will be from 37 mm. to 38 mm. (121·4ft. to 124.6ft.). For a distance of 16 miles the bed and banks of the canal will have to be puddled with clay, the surface of the canal there being above the water-level of the surrounding country. At one point the canal crosses the valley of the river by an embankment provided with a culvert 160 mm. in length. The eleven locks for the descent into the Oder Valley are begun. One of them has a fall of 9 m. (29.52ft.). The question of building a lift besides the series of locks has not yet been decided. The 37 canal bridges are all to be built of steel.

DURING the heavy storm last week there were several disastrous wrecks. Among the most sad of these is that of the Ellan Vannin while she was on a journey from the Isle of Man to Liverpool. For some time the fate of this vessel was uncertain, but later on the position where she sank in the Mersey Channel was discovered. There are at present various theories as to how the accident occurred. A diver who was sent down to make an examination gave it as his opinion that she had been swamped by a heavy sea. Other theories were that she collided with one of the flashing light buoys, and another that a disablement of the steering machinery was responsible for the accident. A later report states that a further examination by divers has shown that the ill-fated vessel had broken in halves.

A COLLAPSIBLE steel dam has, says the *Engineering Record*, been in use for some time in Bear River Canyon, near Garland, Utah, about thirty-five miles above the point where this stream empties into Great Salt Lake. It is essentially a steel crest, built upon an existing crib dam of the Utah Sugar Company, which may be lowered to reduce the water level on the upstream side and enable driftwood and floating matter that might injure the structure to be carried off. In order to place the steel dam in position it was necessary to cut down the old dam 5ft., so that when the steel portion had been built its crest was at the same height as that of the original dam. The steel addition is hinged to the main structure in such a way that it may be folded into a longitudinal pocket or slot, reducing the height about 4ft. and eliminating the danger of water cutting around the ends of the structure during floods and washing out the canals and headgates.

THE United States battleship North Dakota on her official trials considerably exceeded her contract requirements. The contract speed was 21 knots. On her three hours' full-speed trial she did 21.64 knots with 31,400 shaft horse-power. Her maximum shaft horse-power developed was 35,150, while the maximum speed on a mile, uncorrected for tide, was 22.25 knots. A good deal of interest centres in the increased steaming radius made possible by the high efficiency of her Curtis turbines. With a coal consumption of 105 tons per 24 hours at the ordinary cruising speed of 12 knots, as compared with 111 tons burned on her sister ship the Delaware, fitted with reciprocating engines, it is possible for the North Dakota to steam further without recoaling. We understand that calculation from results of her trials have shown that her steaming radius at 12-knot speed is 9000 knots, while at 19 knots it is 4600 knots, and at the maximum speed of 21½ knots it is 3000 knots.

THE whole of the ten 12-in. Mark XI.-XII. B.L. 50-calibre, 67-69-ton guns, forming the main armament of the battleship Collingwood, at Devonport, are, says the *Western Morning News*, now in position on board, together with their working machinery and protecting shields, representing a combined weight of nearly 3000 tons. The expeditious manner in which the outfit of the last pair of barbettes were handled is worthy of commendation, and reflects much credit on all responsible for the movement of the weapons and their mountings. The celerity displayed will be understood from the fact that each of the turntables, weighing 160 tons, was placed in position on board in less than half an hour. The forward state of the boiler-rooms has enabled steam to be raised for working the hydraulic machinery, thus enabling the barbettes to be moved round as required for making adjustments. The last of the 4-in. guns are ready for lifting into position, and it is expected that the entire gun armament will be completed by the middle of the month.

"IN the first nine months of this year," says the *Sheffield Daily Telegraph*, "while thousands of our iron and steel-workers have been tramping the streets wageless and hungry, we imported from foreign countries £5,860,000 worth of iron and steel. At least half that value, in one form or another, represents wages. Taking the average iron and steelworker's wage at 30s. a week, we find that nearly 50,000 foreign workmen have had employment in the production of iron and steel goods for our markets." To put it in another way:—"In each of the first nine months of this year we imported very nearly 100,000 tons of iron and steel, or, to be exact, 877,651 tons between January and September. This is more than 22,000 tons a week. Taking the average wages cost at £3 per ton, this means that by importing foreign iron and steel this year we have been depriving our own workmen of more than £66,000 a week in wages. We have been paying wages to foreign workmen, and profits to foreign employers, while many of our own men, mills, and machines have been standing idle."

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(For description see page 595)

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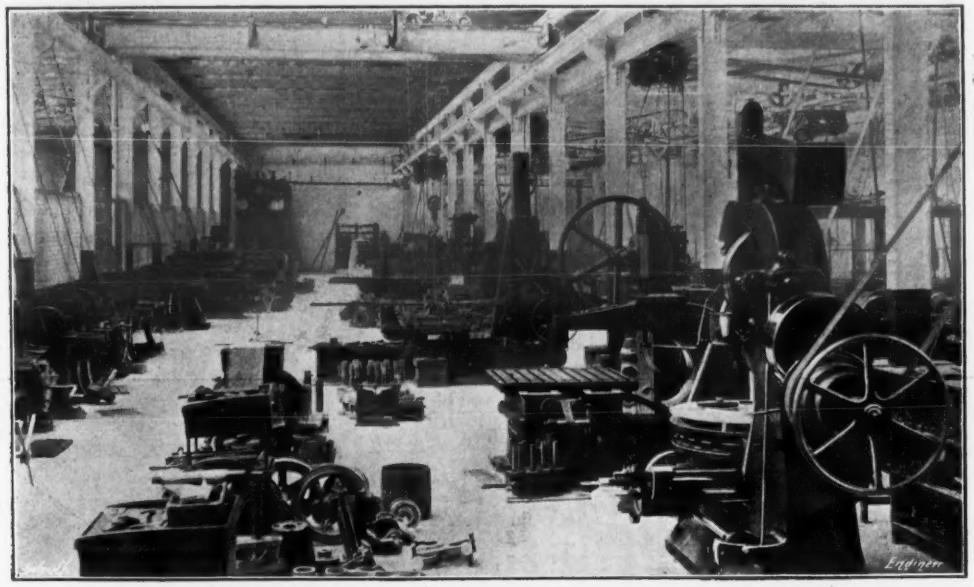

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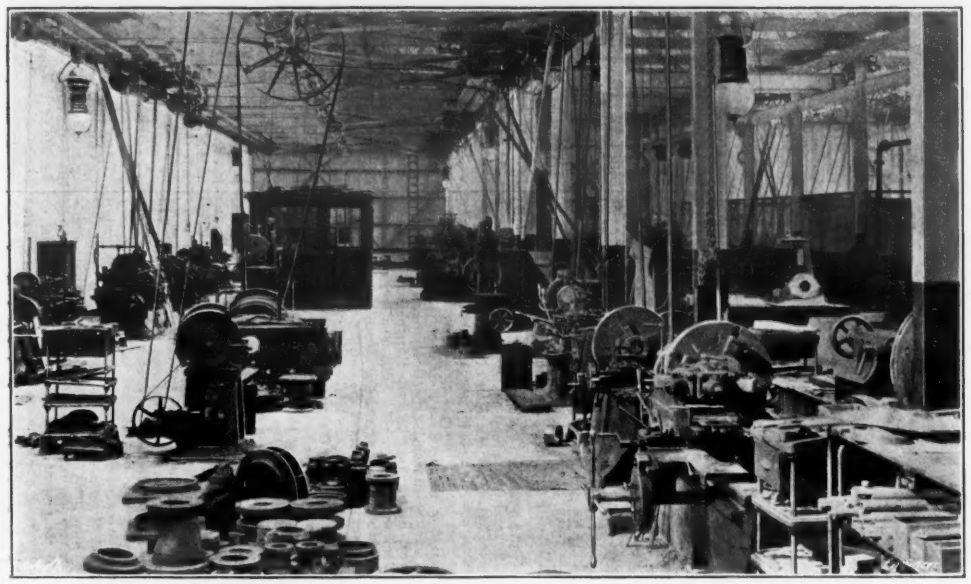

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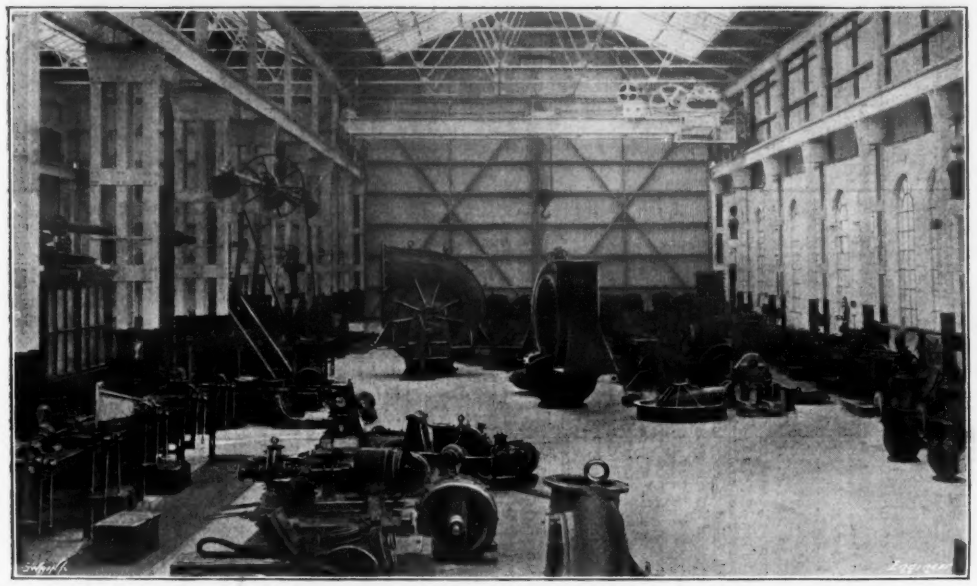

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CONTENTS.

THE ENGINEER, 10th December, 1909.

	PAGE
FISHGUARD HARBOUR. No. II. (Illustrated.)	593
IRRIGATION WORKS OF THE UNITED STATES GOVERNMENT. No. VIII. (Illustrated.)	594
THE WORKS OF DRYSDALE AND CO., LIMITED, YOKER, GLASGOW. (Ill.)	595
IMPRESSIONS OF THE HUMPHREY PUMP. (Illustrated.)	597
THE KING'S DOCK, SWANSEA. (Illustrated.)	597
THE GERMAN NAVAL ARCHITECTS. No. III.	601
THE SMITHFIELD SHOW. (Illustrated.)	602
VICTORIAN RAILWAYS	603
OBITUARY	604
HOSPITAL WARMING AND LIGHTING	604
AMERICAN RAILWAY ACCIDENTS	604
RAILWAY MATTERS	605
NOTES AND MEMORANDA	605
MISCELLANEA	606
LEADING ARTICLES—The German Dreadnoughts—The Common Denominator	607
Apprenticeship—The Exhaust Steam Turbine	608
INSTITUTION OF MECHANICAL ENGINEERS. (Illustrated.)	609
LIFE-SAVING DEVICES IN SUBMARINE BOATS. (Illustrated.)	612
LETTERS TO THE EDITOR	613
A NEW REVERSIBLE MARINE OIL ENGINE. (Illustrated.)	614
SHIPBUILDING NOTES	614
AN AMERICAN LOCOMOTIVE SUPERHEATER. (Illustrated.)	615
THE REDUCING ALLOY SICAL	615
AN INTERNAL COMBUSTION PUMP AND OTHER APPLICATIONS OF A NEW PRINCIPLE. (Illustrated.)	617
DOCKYARD NOTES	618
LETTERS FROM THE PROVINCES—The Iron, Coal, and General Trades of Birmingham, Wolverhampton, and other Districts—Notes from Lancashire	618
Sheffield District—North of England—Notes from Scotland—Wales and adjoining Counties	619
NOTES FROM GERMANY, FRANCE, BELGIUM, &c.	620
AMERICAN NOTES	620
LAUNCHES AND TRIAL TRIPS	620
BRITISH PATENT SPECIFICATIONS. (Illustrated.)	621
SELECTED AMERICAN SPECIFICATIONS. (Illustrated.)	622

TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

J. S.—We have no knowledge of electricity being used for the propulsion of torpedo boats or destroyers. Your informant is possibly thinking of submarines, or has seen some of the projects for electric propulsion.

INQUIRIES.

ANEROID.

SIR,—I recall having seen somewhere a description of an aneriod fitted with a cylindrical chamber, having circumferential corrugations instead of the usual flat chambers with concentric corrugations. I shall be much obliged if any of your readers can put me on its track. H. L.
London, December 7th.

MEETINGS NEXT WEEK.

LIVERPOOL ENGINEERING SOCIETY.—Wednesday, December 15th, at 8 p.m., at the Royal Institution, Colquitt-street, Liverpool. Ordinary meeting. Paper, "The Theory of Suspension Bridges," by Mr. L. H. Chase, M. Inst. C.E.

THE JUNIOR INSTITUTION OF ENGINEERS: BIRMINGHAM LOCAL SECTION.—Wednesday, December 15th, at 8 p.m., at the Great Western Hotel. Mr. H. Horsburgh's paper on "The Design and Maintenance of a Cement Works" will be read and discussed.

THE ROYAL SCOTTISH SOCIETY OF ARTS.—Monday, December 13th, at 8 p.m., in the Hall, 117, George-street, Edinburgh. Communication: "Some Recent Developments in the Use of Producer Gas for Power Purposes," by Professor R. Stanfield.

ROYAL SOCIETY OF ARTS.—Monday, December 13th, at 8 p.m., at John-street, Adelphi, London, W.C. Cantor Lecture: "Aeronautics," by Charles Cyril Turner. Wednesday, December 15th, at 8 p.m. Ordinary meeting. "The Diamond Fields of Brazil," by Hugh Pearson.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 17th, at 8 p.m., in the Institution House, Storey's Gate, St. James's Park, Westminster, S.W. Ordinary general meeting. Papers: "Mild Steel Tubes in Compression and Under Combined Stress," by Mr. William Mason. "Compound Stress Experiments," by Mr. C. A. M. Smith, B.Sc.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 16th, at 8 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Ordinary general meeting. Paper, "Some Quinti a ive Measurements in Connection with Radiotelegraphy," by Dr J. S Fleming, F.R.S. "Efficiency of Short Spark Methods of Generating Electrical Oscillations," by Dr. W. H. Eccles and A J. Makower.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, December 15th, at 7.30 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, S.W. Papers: "The Variations of Currents of Air Indicated by Simultaneous Records of the Direction and Velocity of the Wind," by William Napier Shaw, LL.D., F.R.S. "South American Rainfall Types," by William G. Reed. "The Study of Phenomenal Climatology," by William G. Reed.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 14th, at 8 p.m., at Great George-street, Westminster, S.W. Ordinary meeting. Paper, "Railway Signalling in India," by Charles William Hodson, C.S.I., M. Inst. C.E. Friday, December 17th, at 8 p.m. Students' meeting. Paper, "The Foundation and Construction of Dock Walls," by H. T. Tudsbery, Stud. Inst. C.E. Saturday, December 18th, at 8.30 p.m. Students' Visit to the Printing Works of Messrs. Edward Lloyd, Limited, Salisbury-square, E.C.

THE ENGINEER.

DECEMBER 10, 1909.

The German Dreadnoughts.

AN extraordinary diversity of opinion appears to obtain as to the merits of the German Dreadnoughts compared with corresponding vessels of the British Navy. In Germany there are two distinct classes of opinion. One school holds that the Nassau represents the last word in everything. They point out that she brings as many big guns to bear as the Dreadnought in any position, and that she has in addition a 6in. battery that is lacking in the British vessel, whilst her lesser speed is explained away by the argument that speed is for cruisers, not for battleships. Thus one view of the picture. Quite another aspect is given to it by retired German naval officers, who complain somewhat bitterly that the mountains have been in labour and produced a mouse. These officers argue that the vessels of the Nassau class are simply adaptations of the British Lord Nelson, and that they in no way justify the theatrical secrecy in which their construction was shrouded. They point out that the disposition of the artillery is such that there are always four big guns unavailable; and they ask, somewhat pertinently, wherein lies the triumph of carrying two more big guns than the Dreadnought, and yet in not having a single extra gun to use. They admit circumstances in which the 6in. batteries of the Nassau would be of considerable advantage, but against this contend that British Dreadnoughts, having the speed gauge, would be more or less in a position to choose the range, and would obviously maintain a distance at which the 6in. gun was relatively useless. In fine, supreme disappointment would seem to be the dominant note with these gentlemen.

Between these two conflicting opinions the truth is probably to be found. When all is said and done, it cannot be claimed for the Nassaus that they represent any novelty. They are simply perfectly commonplace developments of the Deutschland class, with big guns substituted for the 6in. upper deck guns of those ships. Of novelty, such as is embodied in the Dreadnought design, there is nothing whatever, and it is further rumoured, on fairly good authority, that they draw at least 3ft. more than they were designed to draw. This may be put down as a case against them. Of our own Dreadnoughts it may, on the other hand, be said that they were produced on the assumption that the importance of the 6in. gun was an exploded idea, and that the naval battle of the future would be entirely decided by the big gun. The more cautious Germans have accepted the big gun, but retained the 6in. also, so as to be on the safe side. The value of the 6in. for battle purposes is one of those problems that only the next naval war can decide. But its utility as an anti-torpedo armament can hardly be exaggerated. That we have somewhat tardily realised this, is perfectly clear from the fact that the 12-pounders of the Dreadnought gave place to 4in. guns in later models, and in the Neptune to 4.7in. guns. It is probable that upon these secondary guns the issue of a fight would be ultimately decided. The big guns in either design are so nearly equal that any battle result must depend upon gunnery pure and simple. The issue is therefore left to the secondary armament and its, at present, unknown value. It is, however, difficult for any unbiassed critic to arrive at any conclusion other than that the German policy of "going slow" and retaining the 6in. gun, is the safer; even though that retention entails corresponding disadvantages, such as unduly increased draught and the overloading of a ship with more guns than she can reasonably be expected to carry upon her displacements. Our Dreadnoughts represent a bold plunge into the unknown, likely either to be quite right or altogether wrong; whereas German design has proceeded on the principle of striking a mean, so as not to be altogether wrong, whatever results the naval warfare of the future may produce.

This peculiar conservatism is characteristic of Germany, which has never believed in giving hostages to fortune. It is an old proverb that "nothing can be won without taking risks." In our Dreadnoughts we have taken these risks with an almost abnormal candour. It rests with the future to show whether we were justified or not. Incidentally, it should be remarked that up to the very last moment a very strong body of opinion in German official circles was in favour of a uniform secondary armament of 4in. guns, instead of the mixed 6in. and 3.4 armament that has been provided. Even, therefore, across the North Sea, absolutely definite opinions by no means prevail. But we feel that it is well that the public should realise that in our naval policy we have taken far bigger steps than other nations have been inclined to take, and that these facts cannot but add to the general sense of unrest that obtains. British naval construction to-day is, by the force of circumstances, of the nature of a vast experiment. We do not pretend to say whether that experiment is right or wrong. That the future may, unhappily, have to decide.

The Common Denominator.

IN the course of the discussion on Mr. Humphreys paper, which was concluded on Friday night, one speaker very aptly remarked, with regret, that there was no common denominator in mechanical engineering to which questions of relative merit could be reduced. The proposition will apply outside mechanical engineering; but confining ourselves to this last, we may say that its meaning is that so long as questions are looked at from different points of view, so long will it be impossible to arrive at anything more than a general agreement. Thus, for example, if we take Mr. Humphrey's reply to Mr. Davey's criticisms, we see that he gained a mere dialectical advantage by showing on the screen a great differential pump, and beside it an internal combustion pump, so small by comparison that he had to explain that it was not a "hooter." Both engines could deal with the same quantity of water; but the Davey engine was lifting it 1500ft. from a mine, while the gas pump could not lift it more than about 15ft. Indeed, it could not do the work of the Davey engine at all. This may be taken as an extreme case, but many others will suggest themselves to our readers. Locomotive performance, for instance, is greatly in need of a common denominator; in fact, the discussion of the subject must be endless unless one is found. The common denominator is, in effect, a standard of merit, and so long as this standard varies, and

each disputant sets up his own, so long will agreement be impossible.

Now, there are, in effect, two standards of merit in mechanical engineering. One is the discharge of its duties by the machine, the other is the amount of money which the doing of the work costs. The cost is the more important of the two in most cases, because it is that which the purchaser of the machine cares most about. We are not arguing that he is right. We are not arguing at all. We are simply putting facts before our readers; and every engine builder, every machine tool maker, knows that the money cost is the first thing considered by the purchaser. One steam engine may be much better from a thermodynamic point of view than another. The cotton spinner cares nothing for that. He does care that his engine runs with such regularity that he can spin fine numbers; that it shall not be stopped for repairs for long periods—we can name very powerful engines which have run for eight or ten years without any repairs worth mentioning—and that the coal bill shall be light. It is obvious, of course, that engines may be made which will satisfy any one or two of these conditions. They will content the souls of some men, while to others they are thoroughly bad, simply because they fail in one respect. High expansion may give a first-rate economical result; but the engine might be quite useless to a cotton spinner, for because on account of its irregular turning moment he could not produce high priced thread. Here money comes in again.

Going a little further, we may say that the first common denominator to be settled is cost. We may take two standards, one the scientific, the other the commercial. Unfortunately, it is the first that seems to attract most attention from those who read papers and those who discuss them. The reason is no doubt that people do not like to talk in public about their private affairs. They will not mention the prices at which they sell their machines, much less what they cost to make. Again, those who use them are not often disposed to speak about their coal or oil bills. Unfortunately, indeed, the steam engine or the gas engine user, even if he attends the meetings of engineering societies, rarely contributes to the general store of information. The result is that a tendency exists to ignore the commercial side of mechanical engineering; and when a listener who has heard a great deal about the relative merits of two engines expressed in thermal units asks what that means done into pounds, shillings, and pence, it comes as a shock to his hearers. On Friday night a comparison was drawn between the cost of working with producer gas engines and steam engines. The argument was all in favour of the gas engine, expressed in weight of fuel required per hour to develop a horse-power. But the aspect of the matter changed when it was pointed out that the coal used by the steam engine was slack, costing 6s. 8d. a ton, while the gas producer worked with anthracite, costing over 25s. a ton. Here the cost of fuel was the common denominator, not the weight of fuel.

It is certain that if only people would agree when they entered upon a discussion that they would keep in view one, or, at the most, two definite points for consideration, disputes would lose much of their acrimony. They would be shortened, and their value would be very much increased. So long, however, as a multitude of factors is raised for consideration, so long will it be unlikely that maximum good will come of the interchange of opinions. If the behaviour of superheated steam in a cylinder is to be mixed up with that of saturated steam in the superheater, and that again with the relations existing between the superheater and the furnace and boiler, nothing but mental confusion can result. The common denominator of the steam user is in this case very simple. On the whole, how much will the annual total outlay on power be reduced by using superheated steam? This is not the point of view favoured by the man of science. He does not think along such a line. He is solely interested, not in saving money, but in reducing the missing quantity, or getting more thermal efficiency. This is to be regretted, for the utility of the scientist might be greatly augmented if he would refuse to regard "money grubbing" as derogatory to pure science. The days are, we hope, past when a very eminent mathematician boasted in his college that he had never produced a formula of the least practical value in his life. There are among us now a limited number of scientific men who have done good service to practical engineering, and who are proud of it, although it means in the end only pounds, shillings, and pence. Their numbers may be increased with great advantage.

It may, perhaps, be said that we have forgotten the other common denominator—to wit, efficiency—efficiency in the fullest and broadest sense of the word. We have done nothing of the kind. Not much examination is required to show that efficiency is in the main swallowed up by and included in the commercial standard. For example, a locomotive engine might be highly economical in every way, costing little to build, wanting few repairs, burning little fuel, safe, fast, and steady, and yet terribly expensive to work, because it could not keep time without a pilot. Here we are down once more to the bed rock. A duty has to be performed—that of hauling trains. What will the performance cost? It is because this way of looking at engineering questions is so inadequately appreciated that papers and discussions are so often disappointing. To listen to some speakers it might be imagined that they were in that happy position when money is of no consequence; while others appear to consider all questions of pecuniary profit and loss as beyond the province of engineering societies and institutions of all kinds. All this is a mistake, and does harm, because it deprives the world in many cases of the aid which well trained and powerful intellects could give. The scientific engineer devotes his energies to saving small quantities of fuel, or discovering where heat escapes. If he could devote his abilities to showing how maximum efficiency—we have tried to explain what a large meaning the word has—can be combined with minimum expenditure, it is at least probable that he could accomplish something noteworthy. The commercial factor is, we repeat, *the* common denominator.

Apprenticeship.

Anyone who listened to the series of seven-minute speeches—dull, instructive, or lurid, according to the speaker—at the Mansion House Conference on Friday last, must have been left with the impression that the education of youths of the artisan class in this country is chaotic. The impression is perhaps not far wrong, for at the present time there is, of course, no such definite scheme of training as the bound apprenticeship of old. On the other hand, however, it must be borne in mind that if a different type of training or education had been required, it would have grown up with our industrial progress. Apprenticeship died because apprenticeship was not wanted. It did not fit in with the factory system, and it became an anachronism. That it can be resuscitated, save in a small way, we do not believe, unless the world resolves to put the clock back one hundred years, throw the bulk of its machinery to the winds, and stop once for all the specialised operation.

We find ourselves wondering sometimes when we listen to discussions on apprenticeship if the speakers have really grasped the secret of cheap production; if they really understand that the manufacturing methods which provide them with all sorts of commodities at absurdly low prices would be impossible if it were not for a system of manufacture which is as inimical to apprenticeship as fire is to water. Let us take one familiar example, out of many score which might be selected. The bicycle chain that we buy now-a-days for a few shillings would have cost in days gone by as much per link as we now pay for the whole. It is manufactured even in single works by the mile, and from beginning to end there is no hand work on it, in the handicraft sense of the word. Depending upon the nature of the chain, there may be from twenty to thirty operations on every link, and each one of those operations is performed on a highly specialised machine by an operator who has literally nothing else to do but feed the machine. In nearly all chain factories we believe girls are employed on the work, and we doubt if a more depressing spectacle is possible than a large building full as it can hold of stamping presses, drills, &c., before each one of which is seated a young girl, frequently no more than a child, hour after hour, day after day, pushing with deft fingers a small atom of steel into the insatiable mouth of the machine—a machine which has been endowed with a higher intelligence, within its limited capacity, than the human operator. What opening is there for apprenticeship under such a system? And what opening is there for apprenticeship under scores of occupations that make no greater demand upon the knowledge and skill of the artisan? Absolutely none. The employer asks for the display of very little intelligence. All he requires is a measure of manual dexterity, so small that it may be acquired in a few hours, a certain very small degree of the power to select which, though it could be given by machinery, is cheaper purchased from a human being. We have laid stress upon this point because, when we discuss the technical training of boys and girls, we absolutely must not lose sight of the fact that, whilst on the one hand we talk of improving their intelligence, we are on the other tacitly degrading it. Competition, and the necessity of satisfying the millions, has rendered the invention of rapid and cheap processes inevitable, and every one of those processes depends for its success upon the amount of skilled labour per unit of product—not that it can employ, but that it can dispense with. That is a fact we must bear in mind. The clothes we wear, the pens we use, the cycles we ride, the matches we strike, and a hundred other commodities so familiar that the process of manufacture has never cost us a thought, are made by methods which depend for their success upon the degradation of the intelligence of the operator. For this state of affairs no one is to blame; the whole world is responsible. It is the mud which Progress has splashed over her garments in her impetuous haste.

We shall perhaps be told that this class of labour represents only a small fraction of the whole, and that although in it apprenticeship is impossible and unnecessary, in others it is possible and beneficial. That is true, but true only to a limited extent. There are, of course, many industries in which apprenticeship could be served, but it is extremely doubtful if in many it would be industrially profitable. The object of apprenticeship is to teach a youth all the branches and mysteries of a given trade, and in the old days it was necessary that every man should know all those branches and mysteries before he could describe himself as a qualified journeyman. Now in very many industries, and certainly in many branches of mechanical engineering, it is neither to the profit of the employer or the workman that the latter should know more than a very limited amount about any save one specialised operation. As long as that is the case a revival of the bound apprentice is impossible. We do not deny for a single instant that from many points of view apprenticeship is desirable. We thoroughly believe that the old system turned out better men, and that the steady training had a very good effect upon the character of the youths; but, at the same time, we cannot shut our eyes to the fact that it cannot be made to fit in with modern conditions. The unions have recognised this, for in many cases they have formally withdrawn, or allowed to fall into disuse, the qualifications that were at one time demanded of members. Professors also have recognised it, and they make a practice now of condemning premium apprenticeship, and urging their students to enter the shops as ordinary workmen for what small pay they can obtain. On all hands, indeed, the decline of the bound apprentice is accepted as practically inevitable. That is a fact which we believe to be indisputable, and if, as we all recognise is desirable, some better training of our young men is to be secured than that which at present obtains, we must look for it—we say it with regret—in some other direction than the revival of the bound apprentice.

The Exhaust Steam Turbine.

The utilisation of waste heat is a matter of the highest importance, and one which for several years past has exercised the minds of many engineers, and many and various have been the attempts to solve the problems it presents. We need only recall the SO_2 engine which about six years ago was brought to notice, and was taken up by numerous firms of engine builders of the highest standing. Excellent results were obtained, and the intrinsic difficulties of dealing with a substance like sulphur dioxide, owing to its rapidly corrosive action under certain conditions, and to the necessity of absolutely tight gland packings, had been overcome on a practical and large scale, at any rate up to a point. But the advent of the exhaust turbine has entirely stopped the development of the SO_2 engine and all similar devices, although the thermal economical results obtainable are not quite so good. The steam turbine, however, has the advantage of greater simplicity; there is no change of working substance, the capital cost is less, and although, as above pointed out, the SO_2 engine had reached a practical stage, yet the very smallest leak in its condenser meant the production of sulphuric acid and complete collapse of the condenser in a few hours. Very special jointing of the condenser tubes was, therefore, necessary, and it would have taken some years of experience before it could be said that any security could be felt that this danger no longer existed. As is well known, the reason the reciprocating steam engine cannot take advantage of a very low vacuum—say over 27in.—is that the

pressure of steam is then so low and the volume so great that an impractically large cylinder would be needed. In the SO_2 engine advantage was taken of the fact that the vapour pressures of that substance are high at even quite low pressures, and thus small cylinders could be used. In the exhaust turbine the pressure of the steam does not directly come into play, but it is the steam velocity that is the determining factor, and this latter depends only on the heat fall. It is useful to note, in this connection, that a heat fall of 5 B.Th.U. produces theoretically a steam velocity of 500ft. per second, but practically slightly less, and that in the neighbourhood of 27in. vacuum this heat fall represents a difference of pressure of only 1.2 lb. per square inch, and the specific volume is 250 cubic feet, whereas in the neighbourhood of atmospheric pressure a difference of pressure of 10 lb. per square inch is needed, and the specific volume is 25 cubic feet. It is further to be observed that the turbine is more efficient at the low-pressure end than at the high-pressure end, because the viscosity and leakage losses are less. The above are the broad reasons why exhaust turbines can generally be advantageously applied.

In practice two distinct cases present themselves. In the first the reciprocating engine is of the non-condensing type; in the second it is of the condensing type. When a non-condensing engine has to be dealt with it may be assumed that the reason is that, owing to the difficulty and cost of obtaining condensing water, there would be no economical gain in making the engine work condensing. The greater gain due to an exhaust turbine may turn the scale in favour of condensing. No change need be made in the reciprocating engine, and it is to be observed that the cylinders are of the right ratio. The engine merely exhausts into the turbine instead of into the air, and may be said to know nothing about the change. In this case, with a moderate vacuum of 24in., the exhaust turbine can develop approximately 60 per cent. of the power of a moderately economical non-condensing reciprocating engine; thus the steam consumption per indicated horse-power is reduced by the addition of the exhaust turbine by 37 per cent. If a good vacuum of, say, 27½in. is obtained the increase of power is about 90 per cent., and the reduction of consumption per indicated horse-power is 47 per cent. It will thus be seen that, even with a moderate vacuum, good results are obtainable. For instance, if it be supposed that the reciprocating engine requires 20 lb. of steam per indicated horse-power, then with a 24in. vacuum the addition of an exhaust turbine will enable an indicated horse-power to be obtained for a consumption of 12.6 lb. of steam. In the second case, when a condensing engine has to be dealt with, if the engine is very economical and is not overloaded, the addition of an exhaust turbine will not be advantageous. But if the engine is uneconomical, or if it is overloaded, there will be an advantage, and the more uneconomical and the more overloaded the greater the advantage. Mr. S. N. Bailey, in a recent paper read before the Manchester Association of Engineers, gives an example of an economical but overloaded engine. Originally it worked at its economical load with a steam consumption of 12.2 per indicated horse-power, but in course of time more and more work was added until the engine was greatly overloaded and the consumption went up to over 13 lb. The exhaust turbine, which has been installed, will allow of still more load being put on, and, as the vacuum has been improved at the same time, the steam consumption will be reduced to about 11 lb. per indicated horse-power. Mr. Bailey also gives an instance of a very large exhaust turbine of 5000 kilowatts capacity which takes steam from two 7500 indicated horse-power Allis Chalmers reciprocating engines. At the moment this is probably the largest exhaust turbine in existence, and it is interesting to note that on the above figures it adds 50 per cent. to the power available.

The case of numerous small engines, generally, if not always non-condensing, delivering their exhaust into one turbine must not be omitted. It was probably one of the first cases put into practical operation, and it admits of very great economical gain, because such small engines are extremely uneconomical. Such engines very often work with great variation of load; that is, they deliver varying amounts of exhaust steam, and to equalise matters, as far as possible, Rateau designed his accumulator, which at first consisted of a large quantity of scrap iron placed in a boiler shell, but now is a special arrangement of heat storage in water. This device gave Rateau a great lead in the application of exhaust turbines, which naturally were of the type bearing his name. Other manufacturers, however, soon realised the commercial advantages of the system, and now every type of turbine is used with low-pressure steam. Controversy has inevitably arisen respecting the merits of the various types, and in particular whether the impulse type or the reaction—or strictly impulse reaction—type is most suitable. Complete discussion would be too lengthy; we will content ourselves by pointing out that the hydraulic efficiency of the impulse type is, roughly, 75 per cent., and that of the impulse reaction is, say, 78 per cent.; viscosity losses are, as a rule, less with the latter than the former, but at high pressures leakage losses are greatly in excess in the case of impulse reaction, those of the impulse type being almost negligible, so that at high pressures the impulse type has practically the greatest efficiency. Hence the advantage of the combined type now coming so much to the front. At low pressures, however, the leakage losses are small, so that the impulse reaction type is practically the most efficient. The impulse type exhaust turbine must, therefore, seek for advantages other than economical ones, and it is difficult to see where they may reside.

Although a good vacuum is essential for good economical results, and a turbine can take advantage of a good vacuum in a way a reciprocating engine cannot do, the cost of obtaining such a vacuum may, in some cases—when water is scarce, for instance—be prohibitive, and, in the paper already referred to, Mr. S. N. Bailey truly remarks: "In aiming at a high vacuum, we can easily expend in capital outlay and power required to work the condensing plant more than can be saved in steam consumption; on the other hand, we can as easily cut down these figures to a point where we do not get a sufficient return from our exhaust steam." His concluding sentence is also worth quoting: "A mighty waterfall appeals to the layman as having capacity for enormous work; its very roar seems to strike it home to him, but how many consider the silent pouring away of power through chimneys, or in the more audible and visible discharge of steam into the air, surpassing a thousandfold the power of Niagara?"

INSTITUTION OF MECHANICAL ENGINEERS.

AT last Friday's meeting of the Institution of Mechanical Engineers the adjourned discussion on Mr. Humphrey's paper, entitled "An Internal Combustion Pump, and Other Applications of a New Principle," was resumed, when a great deal was said about the new pump's merits and demerits, and the sphere of usefulness which it has before it. The President, Mr. J. A. F. Aspinall, occupied the chair.

Professor A. Chatterton, who was the first speaker, remarked that at the previous meeting the author's pump had been discussed from the point of view of the large user, but he intended to deal with it more particularly from the small user's standpoint. In the south of India he had been endeavouring to introduce oil engines for driving pumps for irrigation purposes. About 200 pumping stations of that kind had been put down. His experience had shown him what the people wanted for lifting water for irrigation purposes. Where land was valuable it was undesirable to have a pump that took up a lot of room, but for irrigation purposes in India that was of little importance. On page 10 of the paper the author had stated that the length of pipe between the combustion chamber and the high-level tank must be sufficient to contain such a mass of water that its kinetic energy at maximum velocity should ensure the burnt gases being expanded to atmosphere. This, it was stated, was the limiting condition, but the pump would work with any greater mass of water. He thought that if the pipe was not long enough the water would come to rest too rapidly. One great advantage of Mr. Humphrey's pump was that of being able to get rid of suction pipes. They all knew the trouble that foot valves gave.

Turning to the question of efficiency, the speaker said that according to Professor Unwin's report of the trials carried out at Dudley Port, when working at maximum capacity the pump required 12,000 British thermal units per pump horse-power hour, and at two-thirds load 13,596 units were required In India eight 160 horse-power Diesel oil engines had been put down for lifting water 15ft. In trials carried out two years ago it was found that at full load these engines required 13,000 British thermal units per pump horse-power hour. At two-thirds load the figure rose to 17,000, which was a great contrast with the Humphrey pump. He had found that with a small suction gas plant running in India and using charcoal 14,000 British thermal units were required per pump horse-power hour. As regarded oil engines working with residual petroleum and driving centrifugal pumps with open impellers, he had found that 50,000 British thermal units were required per pump horse-power hour. With pumps having closed impellers the figure was reduced to 40,000. Thus it would be seen that the Humphrey pump required only about one-third of the amount of fuel as compared with small oil engines driving centrifugal pumps. It appeared that the result of using the new pump in the place of small engines and pumps would be the means of using one-third of the fuel, and also saving the greater part of the cost of lubricating oil.

The speaker then went on to refer to the importance of providing the Indian agriculturist with pumps having simple mechanism. The men who had charge of the pumps in that country only got about 5s. a week, and they were not good at dealing with complicated things. The Humphrey pump got rid of practically the whole of the mechanism, and it seemed to him that it had a great future before it in India. Some years ago a commission which was appointed to report on the irrigation question estimated that there were about 16 million acres of land which might be irrigated with advantage. He thought that there was probably room for £60,000,000 worth of pumping plant. There were about 8½ million wells throughout the whole of India. He thought that the author's suggested arrangements for compressing air might well be employed for raising the water from the wells in India. A most important point was the question of the sources of fuel. There were no gasworks in that country, and it would not be practicable to put up suction gas plants of the ordinary kind. Something simpler than the arrangements necessary for the use of petrol was required for the native. Small suction gas plants worked with wood in sizes from 4-5 horse-power were needed. He fancied that few people had any conception of what the present methods of pumping in India cost. It was carried out to a large extent by cattle, and the cost was enormous.

Mr. Liddell Simpson remarked that at the last meeting Mr. Davey did not seem to realise that the comparison which the author had made in his paper referred to pumps working at low lifts. He thought that his comments about steam engines were very remarkable. The steam engine which had been selected for comparison was driving a high-duty pump with a low lift, and its consumption was considered very good. He was aware that the performance could be improved somewhat with the use of superheated steam. He had recently had an opportunity of seeing a large Humphrey pump in use. It was a very interesting plant. The small amount of mechanism

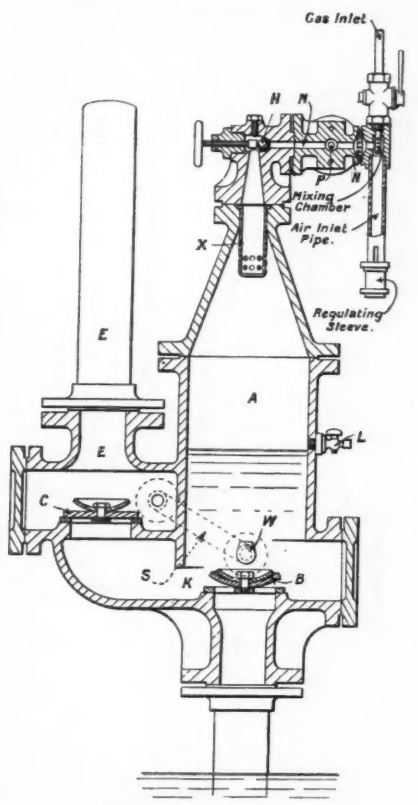


Fig. 1—JOY'S GAS PUMP

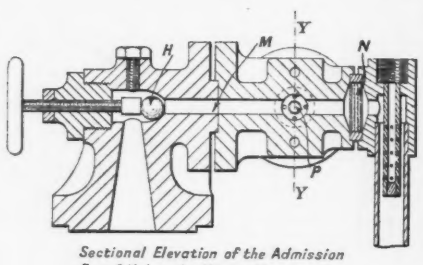
was really remarkable. The pump referred to in Professor Unwin's report was not working under the best conditions. He thought the arrangement shown on page 14 of the paper was a very good one for altering the periodicity by varying the length of the discharge pipe. It would be noticed from that diagram that there was a by-pass which enabled the length of the discharge to be varied in a very simple manner. He would like to ask the author whether, in view of the exhaust being so cold, he had ever thought of exhausting the gases into a vacuum to enable the pump to suck the water up, for the present pump in its simplest form had its suction pipe below the water level. The speaker then went on to refer to the small amount of space which the new pump occupies as compared with the ordinary slow-speed steam pumping engines, and drew attention to a diagram on the wall which had been prepared to illustrate this point.

Dr. Hele-Shaw first of all referred to page 29 of the paper, where the author deals with the question of jet propulsion for ships by means of his pump. It seemed to him that the bulk and weight of the pump precluded its use for passenger steamers, or even on fast-going cargo steamers. The use of petrol for such service was out of the question. The speaker, however, dealt mainly with a statement which the author makes on page 2 of his paper. In that part of the paper Mr. Humphrey had stated that the efforts had all been directed too much along the ordinary lines of ordinary pumps, in so far as the water lifted had always been forced past a non-return valve, and the operation of such a valve with the explosive force behind it had been inevitably disastrous.

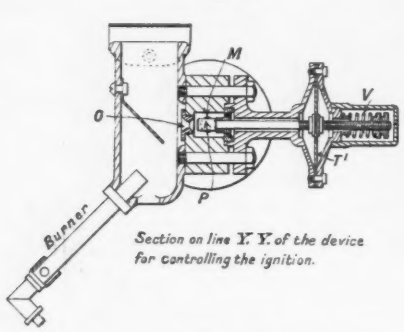
He could not agree with that statement, for he had

tested a pump of that kind, invented by Mr. Bertram Joy, which operated in a highly satisfactory manner, Then Dr. Hele-Shaw went on to describe this pump with the aid of a diagram on the wall, which diagram is reproduced in Fig. 1. The pump, it was explained, was designed on quite a small scale. It lifted 1050 gallons per minute, against a head of 18ft. The suction lift was 2ft.

The speaker then went on to describe the action of the pump, which is as follows:—To obtain an initial explosion means, such as a hand pump, is provided for the introduction into the working chamber through a cock, such as L, of a combustible gas. The initial charge having been introduced into the working chamber A, is automatically ignited at the port O—Fig. 2—by means of the burner. The pressure due to the explosion drives the water—or air in the case of the chamber containing no water at starting—out of the working chamber through the delivery valve C, the suction valve B closing automatically. When the water in the working chamber is so far discharged as to uncover the port K, the exhaust gases pass into the delivery pipe or rising main E, at first by their own pressure, and afterwards by the kinetic energy of the column of water in the pipe or main. As soon as the water in the rising main becomes stationary, or nearly so, the pressure due to its head causes a spray to issue from the jet W, which scours the interior of the working chamber, and by its cooling effect causes the hot gases left in the chamber rapidly to contract, and so increases the suction effect. When the pressure in the working chamber becomes equal or nearly equal to atmosphere, both the valves H and B open, the former to admit gas and air and the latter to allow a fresh charge of water to flow into the chamber. Meanwhile, the partial vacuum in the port or passage M has the effect of closing the ignition valve P, thus preventing ignition occurring until the pressure conditions approximate that of the atmosphere, by which time the working chamber is again charged with combustible gas and water. As soon as the



Sectional Elevation of the Admission Port & Valve, the Mixing Chamber & Firing Port.



Section on line Y. Y. of the device for controlling the ignition.

Fig. 2—IGNITION GEAR OF JOY'S PUMP

depression in the port or passage M is insufficient to overcome the spring V through the medium of the diaphragm T', the ignition valve P opens and explosion ensues. This cycle of operations then continues until the supply of explosive mixture is shut off. In the passage M there is a gauze screen N, the function of which is to prevent firing in the mixing chamber, the screen acting on the Davey lamp principle. The opening of the valve-box into the working chamber takes the form of a perforated pipe X, the purpose of which is to protect the valve H from the water jet. It will be seen that the jet W is connected with the delivery pipe by means of a pipe S, so that the jet is constantly under the head of water in this pipe. The pipe S is fitted with a cock—not shown in the drawing—for the purpose of shutting off the jet when starting. The lift of the pump can be varied by altering the opening of the valve H with the hand wheel on the left. An illustration of an actual pump of this type is given in Fig. 3.

Dr. Hele-Shaw said that he was prepared to admit that the gas consumption of such a pump would be somewhat high, but drew attention to the fact that it was sometimes expedient to sacrifice a little in that direction for the sake of simplicity. He then went on to refer to some tests on various types of small pumps, including the pulsometer pump and the injector, the latter, he said, using in one instance as much as 418 lb. of steam per horse-power hour.

Mr. Emerson Dowson, among other things, referred to the fact that the author had given the results of an analysis of the gas used in his pumps; but he thought that if Mr. Humphrey had included the results of analysis of the exhaust gases the information would have been more interesting, for it would show whether complete combustion was obtained or not. The speaker also referred to page 38 of the paper, where the author states that with his suggested electric station, with hydraulic coupling between the gas plant and electrical machinery, a Board of Trade unit could be generated with 2 lb. of anthracite coal. He would point out that gas engine makers were prepared to guarantee 1 lb. of coal per brake horse-power, and adding 50 per cent. to bring this to electrical Board of Trade units, gave 1½ lb., as compared with Mr. Humphrey's 2 lb. Even with bituminous coal a Board of Trade unit could be generated with 1½ lb. of coal.

Mr. O. H. Mueller, of the Worthington Pump Company, said that, looking at the water end of the new gas pump, it would be seen that it had valves, and he thought that they would be the means of precluding the use of the pump for a large number of purposes, particularly as the valves were inaccessible. Inspection of the valves would necessitate employing the supply tank, and arranging a sluice valve in the pipe to the high level tank or air chamber. The size of such a sluice valve would have to be such as not to restrict the passage of the oscillating column of liquid. For pumps of comparatively small capacities sluice valves would be needed several feet in diameter. The operation of inspecting or replacing the suction valves would be extremely tiresome. In ordinary reciprocating pumps, single or double acting, the free area of the suction valves was equal to the capacity divided by the velocity allowed through the valves. This had to be multiplied by two, as the suction valves were only open half the time. The same velocity being allowed for the discharge valves as was customary, the total free area of all the valves was equal to four times the capacity divided by the velocity through the valves. In the new gas pump, which was operated by one four-cycle cylinder, the time allowed for the water to pass through the suction valves could not possibly be more than a quarter of the duration of a complete cycle, and possibly less. Therefore the valve area was at least equal to the total valve area of a reciprocating pump of the same capacity. With a duplex two-cycle arrangement, the area could be reduced to about one-half. But that only applied to very low heads, such as could be directly overcome by the motor cylinder without storing energy in an auxiliary air vessel.

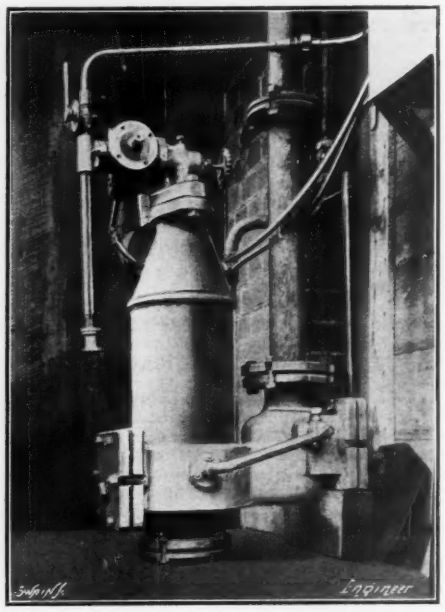


Fig. 3—JOY GAS PUMP

By reason of the expansion being carried below atmospheric pressure the mean effective pressure in the gas cylinder was a good deal less than in an ordinary gas engine, and he thought that any head above 60ft. would necessitate the use of an air vessel and check valve on the discharge pipe, as shown in Fig. 9 of the paper. The time allowed for the water to pass through the check valve—or, rather, a plurality of check valves—was only a fraction of the time allowed for it to pass through the suction valves, so that they would have to be much larger. While a reciprocating pump delivering 1000 gallons against 120ft. required half the valve area of another delivering 2000 gallons against a head of 60ft., a Humphrey pump for the first-mentioned condition required double the valve area, or four times as much as the reciprocating pump. That he considered was a great disadvantage. In order to convert the gas pump into a practical machine for pumping it would, in his opinion, have to be combined with a water motor and pump both of the reciprocating or rotary type. The principle would have to be adopted which the author had illustrated in Fig. 19 of his paper. Another thing which the speaker drew attention to was that the new pump requires a constant head on the suction side. He would like to ask in how many cases that was available. Such a condition was certainly not to be found on the banks of the Thames or on the banks of any other river, nor at the sea shore or with wells. Turning to the question of indicating the pump the speaker said that he would like to ask the author, whether in view of the slow motion of the water in the pump, it would not be possible to fix a gauge glass and to follow the motion of the water in the pump by the hand that pulls the indicator down, and to correct the card for the conical shape of the explosion chamber.

Captain Sankey called attention to Fig. 16 in the author's paper, where he gives the theoretical thermal efficiencies of the "air standard" of the Otto cycle and of the pump cycle, and also to Fig. 17, in which the practical thermal efficiencies had been obtained by multiplying the theoretical efficiencies by .71. The practical efficiencies thus calculated were correct for the Otto cycle, but had not been obtained with the pump cycle. Thus, taking the tests reported by Dr. Unwin, in which the compression was 44.7 lb. per square inch, it would be seen from Fig. 17 in the paper that the calculated thermal efficiency was 33 per cent., and if it was assumed that the friction losses were 10 per cent., that the gas producer had an efficiency of 80 per cent., and the calorific value of the coal was 14,400 then the coal consumption worked out to .75 lb. per pump horse-power, instead of 1.063 given in the tests. It followed that the practical thermal efficiency was only 23 per cent. It might therefore be assumed that in due course much more economical results would be obtained with the Humphrey pump. The speaker also referred to a hot air mercury pump, particulars of which had been sent to him by Professor Harold Dixon. In 1885, he said, the professor was making some experiments with gases, and left three gas tubes standing over night. The upper ends contained gas heated internally by a spiral wire carrying an electric current. Next morning

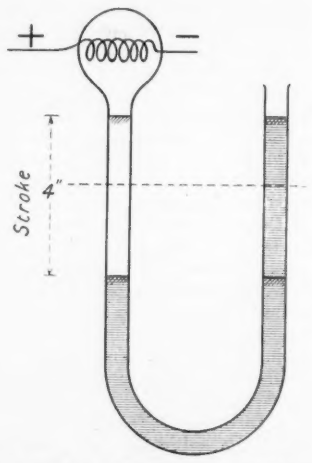


Fig. 4—DIXON'S EXPERIMENTAL APPARATUS

he found the mercury in all the tubes throbbing up and down. The explanation was that the slightest disturbance produced a "pendulum" motion of the mercury, alternately compressing and expanding the gas in the top of the tube. On compression the gas would be slightly heated, and during expansion it would be cooled by the cold surface of the tube exposed by the mercury. The stroke of the "mercury" would thus be increased at each swing, and the limit would be reached when the friction of the mercury in the tube was balanced. The diagram—Fig. 4—illustrated the arrangement. Obviously if water were poured into the open leg when the mercury was at the bottom of its stroke, it would be pumped up, and, pointing to another diagram, which is reproduced in

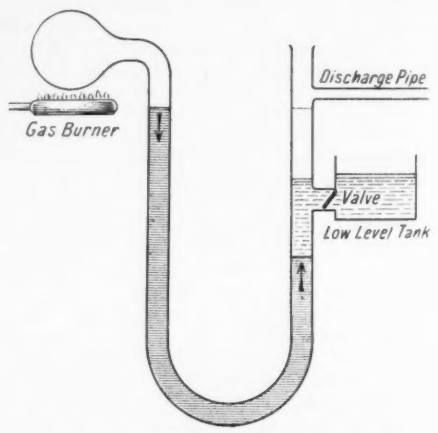


Fig. 5—MODEL PUMP

Fig. 5, the speaker said that by providing a tank, as shown, the apparatus could clearly be made to work as a pump.

Mr. Henry Lea said that at the bottom of page 48 of the paper, the author gave the figure 1.063 lb. for the fuel consumption of his pump, per pump horse-power hour, when using anthracite. On page 50 there were three figures relating to the fuel consumption of steam engines. Two of these related to triple-expansion engines, and one to a compound engine. The figures were 1.66 lb. and 1.69 lb. of coal per pump horse-power hour for the triple-expansion engines, and 2 lb. for the compound engine. That which was most important, however, was the question of £ s. d. Assuming coal to be purchased for the steam engines at 10s. per ton, then multiplying that by 2 gave a figure which would serve the purpose of comparison for the compound engine. The figure was 20. Multiplying 1.66 by 10, gave 16.6 for one of the triple-expansion engines. Assuming anthracite used in the producer to cost 25s. per ton, the figure for comparison in that case would be 1.06 multiplied by 25, which equalled 26.5. Taking the cost of Mond gas at 2d. per 1000 cubic feet, and working it out, it would be found that by buying Mond gas the purchaser was not getting all the heat that was in the slack from which it was produced. He was paying as much for the heat obtained out of the Mond gas as he would have paid had he purchased the original slack at 35s. a ton. Multiplying the author's figure 1.063 by 35 it gave 37. They thus obtained in money values the relative cost of working under four different conditions.

For the Humphrey pump using Mond gas the figure was 37, and when using anthracite in the producer it was 26.5. The figure for the compound engine was 20, and that of the triple expansion engine 16.6. It did appear, therefore, that the Humphrey pump was more economical than any other form of pump, as the author had stated in his paper. Lastly, the speaker referred to the remarks of Dr. Hele-Shaw concerning the high consumption of injectors, and pointed out that it did not matter whether injectors used 400 lb. or 4000 lb. of steam per pump horse-power hour, for all the heat contained in the steam which worked them was returned to the boiler.

Mr. J. V. Robinson, of Richardson, Westgarth and Co., compared the weight of a 1600 horse-power gas engine with that of a 1600 horse-power pump. He said that an engine of that size having 39½in. bore and a 43.5in. stroke running at 100 revolutions per minute with a compression pressure of 120 lb., and using 500 lb. of rich mixture per minute would weigh from 130 to 150 tons with the fly-wheel. Assuming a Humphrey pump of that power to have four barrels 4ft. 9in. diameter and the stroke to be 20ft., the total length of the barrel would be 27ft. with the clearance volume. Also assuming that 1300 lb. of poor mixture were used per minute, the compression pressure to be 45 lb. per square inch and the explosion pressure 100 lb. per square inch, then, based on 1 lb. of mixture before compression occupying 12.5 cubic feet, after compression 5.7 cubic feet, and after expansion 22 cubic feet, the mean pressure was 17.5 lb. per square inch. The weight of water required would be 4570 lb. per pound of mixture, or 176.5 tons in all. To get a sufficient number of cycles the diameter of the pipes would have to be double the diameter of the combustion chamber, or 9ft. 6in. The length of the pipes, including the rising main, would be about 73ft. of 4ft. 9in. pipe, or 36.5ft. of 9ft. 6in. pipe, for each cylinder, or 36.5ft. of 13ft. 6in. diameter pipe for each pair of cylinders; in other words, 73ft. of 13ft. 6in. pipe in all, which would weigh about 206 tons. The cylinders would weigh approximately 50 tons, so that the total weight would be from 425 to 430 tons. Here Mr. Robinson remarked, in quite a matter-of-course manner but amid much laughter, that pipe work was a little less expensive than the machined parts which go to make up an engine, but his calculations showed what a weighty thing a 1600 horse-power Humphrey pump would be.

Mr. Bertram Blount dealt with the question of the effects which the gas is liable to have on the water. He did not think that there was much fear of the water taking up sulphur, nor did he anticipate that any trouble would be experienced with corrosion, nor did he think that drinking water would be appreciably contaminated.

Professor Spooner, who was the last speaker to take part in the discussion, confined his remarks to the question of applying the author's pump to jet propulsion. In view of its great simplicity and its high efficiency, he thought that it had latent possibilities before it in the direction of propelling ships. He noticed that a pump horse-power hour could be obtained for 1.06 lb. of coal, and assuming the jet to have an efficiency of 80 per cent. meant that an effective horse-power could be obtained with 1.3 lb. of coal. It was some years ago since the Thornycroft jet propulsion trials were carried out, but it would be remembered that the low efficiency of the pump was the greatest drawback. He thought that if the losses due to the pump could be got rid of a good deal more would have been heard about jet propulsion.

The author was then called upon to reply. In so doing he confined his remarks almost exclusively to what Mr. Henry Davey had said at the previous meeting, so that the reply was by no means complete, and we venture to suggest that the author was too hard on Mr. Davey, and that he would have done much better had he devoted some of the time at his disposal to the criticisms of other speakers. He said that he thought that Mr. Davey was hardly justified in stating that he—Mr. Humphrey—commenced his paper by endeavouring to establish a comparison between the economy of steam-worked pumps and gas-worked pumps as they existed. Had he made such an effort he would have quoted working results instead of merely making a passing reference to gas-driven pumps and instancing the case of the five pumps belonging to the South Staffordshire Mines Drainage Commissioners.

As regarded those pumps, he had been careful to ascertain that where the gas engines had been erected to replace steam engines, the change had resulted in the pumping being carried out at a reduced cost, and, secondly, that the plants were permanently erected and were intended for permanent working. The report of the South Staffordshire Mines Drainage Commissioners dealt with seven steam-driven pumps and four which were gas driven, and using Mond gas at 2d. per 1000 cubic feet. He had taken the trouble to analyse those costs, and he had found that the average cost per pump horse-power hour for the steam-driven pumps was .543d., and that of the gas-operated pumps .673d. If the fuel figures and the cost of delivering the fuel were alone taken as the basis, then the fuel cost for the steam plants was .248d. per pump horse-power hour, and for the gas plants .269d.

When it was remembered that the steam pumps were on the whole much larger than the gas pumps, the latter did not compare unfavourably with the former, especially when it was remembered that speed reduction gear had to be placed between the gas engine and pumps. He had quoted 18 lb. of steam per pump horse-power hour, but he had not done this before inquiring among large pump users. He was aware that, with high-pressure superheated steam used in large steam pumps working on high lifts, and in conjunction with a very good condenser, a pump horse-power had been obtained with even less than 12 lb. of steam. It was a marvellous result for a slow moving steam engine, but, after all, it was quite exceptional, and he still believed—and he found himself supported by other speakers—that 18 lb. of steam per pump horse-power hour was an excellent average working figure for a compound steam pump. Mr. Davey, after having stated that the pump which took 18 lb. of steam per pump horse-power hour was a disreputable example, had proceeded to make a calculation based on 20 lb. of steam per pump horse-power hour. Taking slack at 4s. 6d. per ton, he arrived at .096d. per pump horse-power hour, whilst he—Mr. Humphrey—had shown that with slack at 6s. 9d., the corresponding fuel cost for the internal combustion pump was below .06d., or less than half the more usual steam fuel figure of .13d.

The 4s. 6d. per ton for slack Mr. Davey stated to be the price paid by the South Staffordshire Mines Drainage Commissioners, who had five large Davey pumps in use. He had just shown the actual cost of fuel for the steam pumps to be .247d., instead of Mr. Davey's calculated figure of .096d.

Mr. Davey had said that making a mass of water provide fly-wheel effect was old. The combustion chamber, mushroom valve and iron pipes were also old. He had naturally made use of such things as he found at hand, and all that he claimed to have invented was a new pump, and not the materials or parts of which the pump was made.

Turning to the question of the pump being large, the speaker said that Mr. Davey had remarked that the pump appeared to be very bulky for its power, and he presumed that he was comparing the pump as such to steam pumps like those made by his firm. If it was a question of comparing the gas pump to a gas engine, then he was only too willing to admit that the apparatus was to be considered bulky, because when the gases were expanded down to atmospheric pressure, it was necessary to provide a chamber much greater in volume as compared with the cylinder of an Otto cycle engine. Also although a pump had been worked at 42 cycles per minute, the speed was slow as compared with a gas engine.

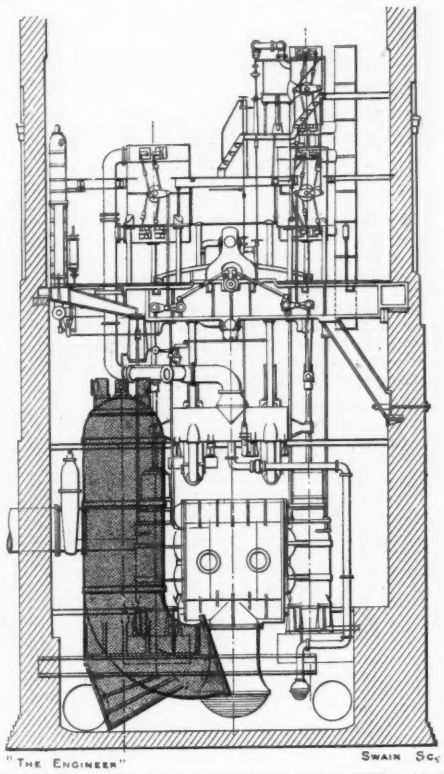


Fig. 6—WORTHINGTON & HUMPHREY PUMP CONTRASTED

But remembering that the pump in its simplest form was admittedly a low-lift pump, and comparing it to a reciprocating steam pump, then it was the steam pump which appeared enormously bulky compared with the gas pump.

He then said that Mr. Liddell Simpson had been kind enough to provide him with a drawing of one of the pumps mentioned by Professor Unwin in his report, namely, a triple-expansion high-duty Worthington pump having a large output. He had superimposed upon it the outline of a recently designed Humphrey gas pump delivering four times as much water as the steam pump. Here the diagram in question, which is shown in Fig. 6, was put upon the screen and the speaker gave the relative dimensions, the space occupied by the triple-expansion engine being 12,327 cubic feet and that occupied by the gas pump 2821 cubic feet. Taking four sets of Worthington engines to give the same water output as one Humphrey pump, these sets would occupy 17½ times the space occupied by the Humphrey pump.

The speaker then went on to make other comparisons of a similar kind, where the discharge pipe was included, these comparisons proving even more favourable from the point of view of space. Although Mr. Davey could not accede to his request and send him a drawing of his pump of greatest output, yet in a letter he had been referred to two illustrations in Mr. Davey's book on pumps, both showing deep well pumps, and therefore not really suited for comparison. Taking the one Mr. Davey seemed to like best, he had made a lantern slide of that part of the pump which was above ground—there was a lot more of it below. It lifted 1500 gallons per minute from a depth of 1500ft. When this drawing was thrown upon the screen an insignificant looking little pipe appeared in the margin. That, the speaker explained, was not the hooter to call the men to work, although it might be thought that it was. It was a Humphrey pump drawn to the same scale and delivering the same quantity of water. The comparison was not of his own choosing, and it was spoilt by the divergence of lift, but it was instructive as far as it went.

Coming to Mr. Davey's statement that if 10ft. or 12ft. is fixed as the maximum velocity of flow in the discharge pipe, the weight of water in the length of pipe between the two lower extremities of the two vertical limbs would have to be from three to four times the total weight of water from the bottom of the delivery limb of the tank, assuming the size of the pipe to be the same all the way through, the speaker said that the statement had no foundation either in fact or theory. He would assume the diameter of the discharge pipe, its length, and its rise all fixed. There remained two other controlling factors, namely, the kind of combustible mixture used, and the amount of combustible charge, both apparently ignored by Mr. Davey.

He would ask the members to imagine that an indicator card of the working stroke could be obtained and divided by vertical ordinates into a number of small parts, then theory required that for each part of the indicator card there would be an acceleration definitely related to that particular part. Of course, the acceleration became a deceleration after the expansion reached a point where the gaseous pressure equalled the pressure due to the static head of water. Those relations held whether the charge was large or small, since the expansion curves might, for the purpose, be supposed to follow the same law. What altered the amount of charge was the time base, and each element of acceleration acted for a longer period as the charge increased. It followed, therefore, that for any definite maximum velocity that might be fixed, there was some definite charge volume which met the conditions. In other words, if it was said that the velocity in the discharge pipe was not to exceed twelve or any other number of feet per second, then it was possible to find the charge volume which satisfied the conditions. On theoretical grounds there was no reason—always remembering the limitation of lift for the simple pump—why the delivery should not be wholly vertical. It was found in practice that there were other conditions which made it difficult to work with a pipe, the length of which was only equal to the height of lift; or, in other words, a vertical pipe only. With such a pipe the cycles per minute might become too rapid to allow the proper quantity of water to enter the pump at each cycle, and for that reason alone it had been found desirable to lengthen the pendulum, so to speak, as the lift increased, and so counterbalance the tendency of an increased lift to unduly quicken up the cycle. Mr. Davey, in choosing a 200ft. lift, necessarily referred to the high lift apparatus in which the gas was combined with an air vessel, and in that case he made his absurd and unfortunate statement that the pump requires 600ft. to 800ft. of pipe. He called it absurd, because excluding the rising main in which the flow was continuous, the pump only needed one-tenth of the length which Mr. Davey mentioned. Finally, the speaker mentioned that analyses of the water had been made to ascertain if there was an increase in the sulphur contents, but with negative results. He had a certificate from Dr. Hertz, of London, showing that there was no SO_3 in water pumped 100 times.

During a visit which Mr. William B. Bryan, Chief Engineer to the Metropolitan Water Board, paid to Dudley Port to inspect the pump at work, he was asked to arrange a test which should be conclusive as regards contamination of the water by pumping. He was kind enough to suggest that all the canal water in stock, tank, &c., should be emptied out and replaced by potable water from the South Staffordshire Waterworks Company's mains. The water then to be circulated by the pump a definite number of times, and samples taken before and after pumping, to be tested by a public analyst. Mr. Harry Silvester, public analyst for the County Boroughs of West Bromwich and Dudley, undertook the analyses, and the programme arranged was carried out, with the results shown below:—

Analyses of Water Circulated through Humphrey Pump.

Sample No. 1.—All canal water emptied from tanks, air vessels, &c., and flushed through. Plant refilled with water from the South Staffordshire waterworks main. Pump run for five minutes to thoroughly mix water, and then No. 1 sample taken.

Sample No. 2.—The pump was run at an average rate of discharge of 2212·5 gallons per minute for 3 hours 20 minutes. Thus, the total water, amounting to 21,000 gallons, was circulated through the pump 21 times.

Certificate from Mr. H. Silvester, B.Sc., F.I.C., Public Analyst, Birmingham.

I have analysed these samples and give you the figures obtained in the accompanying certificate.

The ammonias in the two samples were practically identical, whilst the rise in the oxygen consumed figure, even after 21 circulations, was only ·0008 grain per gallon.

I also made a direct test for sulphuric acid with a negative result.

From these results I am of the opinion that the water is not contaminated by tar or sulphurous acid when pumped by means of your pump.

As the particular sample of water was circulated 21 times, the results are strong evidence of the non-contamination of the water by the gas, when the water is only circulated once, which, I presume, would be the ordinary practice.

I am,
Yours faithfully,
(Signed) HARRY SILVESTER.

Certificate.

I hereby certify that I have analysed the samples of water received from Messrs. The Pump and Power Company, Limited, December 2nd, 1909, and that I find the following results in grains per gallon:—

Mark on Sample.	No. 1.	No. 2.
Free and saline ammonia	·0042	·0034
Albuminoid ammonia	·0064	·0056
Oxygen consumed in four hours at 80 deg. Fah.	·056	·062
Combined chlorine	1·26	1·33
Alkalinity in terms of grains per gallon of carbonate of lime	7·7	7·52

I made a direct test for sulphurous acid, but the result was negative.

(Signed) HARRY SILVESTER, B.Sc., F.I.C.

LIFE-SAVING DEVICES IN SUBMARINE BOATS.

WE received a few days ago from Siebe, Gorman and Co., Limited, of Westminster Bridge road, S.E., a copy of a book entitled "A Diving Manual," which this firm has recently produced. This little book treats of submarine appliances and their uses, deep sea diving, &c., and it has been compiled and edited by Mr. R. H. Davis, the firm's managing director. It embodies a description of the latest deep sea practice adopted by the British Admiralty, and includes chapters on the physics and physiology of diving, and also an account of the diving dress and diving bell, as well as instructions for divers. The whole is delightfully got up and affords excellent reading, but there is one portion in particular which is of special interest nowadays when so much attention is being devoted to the question of saving the lives of men who may sink with a submarine when she founders. It would be impossible to deal separately with each of the various subjects discussed, but we feel sure that a somewhat extended reference to this portion of the book will be of value to our readers; the more so that we are, through the courtesy of Siebe, Gorman and Co., Limited, enabled to illustrate our remarks by means of some of the same engravings as are contained in the book.

Fig. 1—PUTTING ON THE DRESS

Fig. 2—ENTERING THE EXPERIMENTAL AIR DOCK

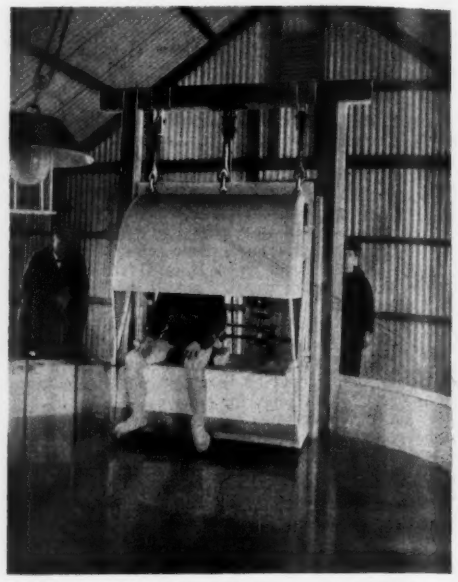


Fig. 3—IN AIR LOCK READY TO BE LOWERED

The problem of saving the lives of the crew of a submarine vessel is by no means easy of solution. Equipment and apparatus which is invaluable on shore is quite useless under water. As Messrs. Siebe, Gorman and Co. explain, it would be quite easy to construct a submarine boat, the crew of which would be safe under practically every conceivable set of circumstances, but such a vessel would be so hampered by her safety devices as to have little or no military efficiency, and since these craft are, at present, only built for fighting, this kind of boat need not enter into serious consideration. In studying the matter of rescue, the designers of the appliances to which we are about to refer have regarded it as essential that the salvage of the vessel and of the crew must be looked upon as entirely separate. Inevitable delays in the arrival of the salvage vessel, and in getting purchases on, conditions of tide, weather, &c., render it almost certain that a submarine cannot be raised in time to save life.

It is taken for granted that an accident which will endanger the lives of the crew will result in the inrush of water in large quantities. A minor accident to the machinery would only result in an involuntary rise to the surface, owing to the reserve buoyancy of the boat, and any ordinary small leakage can be readily dealt with by the machinery at command. When, however, there is a collision, or when, by some other mischance, a hole is made in the hull, the water enters freely, and the effect will be the descent of the vessel to the bottom. This may not be very fast, but, assuming that the water is entering more rapidly than it can be expelled, the vessel will undoubtedly sink and continue to fill, until she is either full, or, if not holed in the top, until the air in her is compressed to a pressure equal to that of the water at the depth in which she has foundered. As soon as the salt water comes into contact with the battery or with the terminals of the dynamo, if this be still working, chlorine is evolved, and the air remaining inside is vitiated.

Having regard to these considerations, it is necessary that something be done, and done quickly

Fig. 4—MAN WEARING THE DRESS

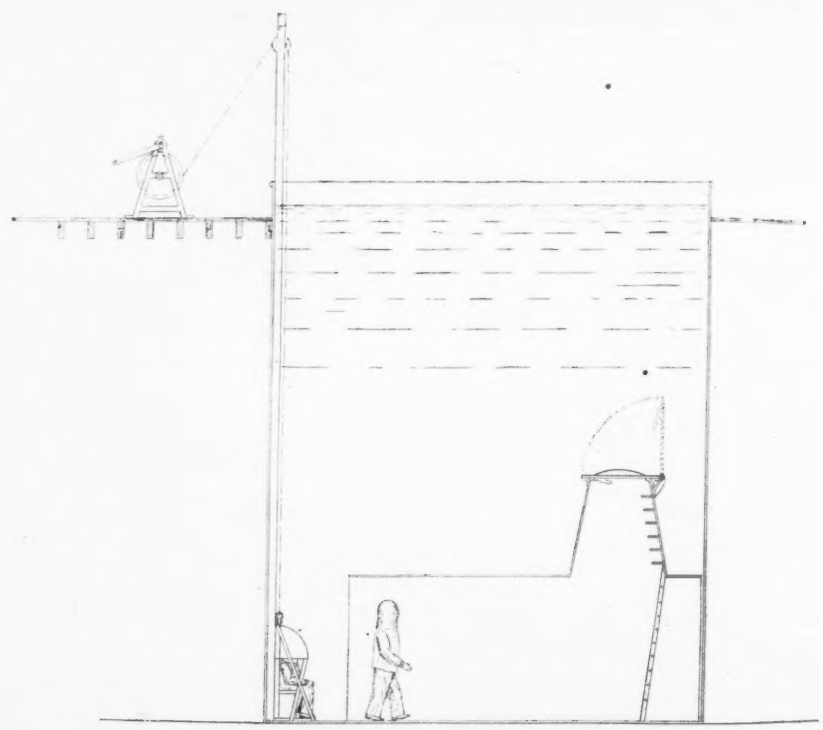


Fig. 5—EXPERIMENTAL TANK AND DUMMY SUBMARINE

It is then pointed out that a life-saving device to be efficient must be able to fulfil promptly the three conditions, *a*, *b* and *c*, previously referred to, and in order to meet them this firm has designed and patented a special form of diving helmet, which is quite self-contained and not dependent on any feature which is liable to get out of order. This apparatus is described and illustrated in the book, and has, we understand, been adopted, after exhaustive trials, by the British Admiralty. Its design and method of use will be understood by the aid of the accompanying engravings. The helmet—Fig. 4—which is made

(*a*) To render the crew independent of poisonous gases,
(*b*) To preserve the crew from drowning in the boat, and
(*c*) To provide means of escape from the boat, and ascent to the surface.

The devices to bring these about at present known are:—

(1) Air locks for escape,
(2) Detachable chambers or life boats,
(3) Self-contained dress for escape.

Air locks alone are of little use, except in shallow water, but combined with (2) or (3) are essential in all methods of escape. The air lock may be a portion of the boat provided for the special purpose, or the general cavity of the boat may be used, in which case the pressure inside the vessel can be made equal to that of the water outside by simply allowing the water to enter, for it is manifestly impossible to open an aperture until the pressures at both sides of it are equal. The great objection to all forms of detachable chambers or large enough to allow the head free movement, is sloped away to fit the shoulders, and is connected to a short jacket of strong waterproof material. In front of the jacket, inside, is a pocket containing a combined air purifier and oxygen generator, consisting of two small chambers formed in one case. These chambers are charged with a patented substance which, when in contact with the water vapour of the breath, gives off pure oxygen gas and forms a caustic alkali. The alkali in its turn takes up the carbonic acid gas of the respired air and forms an alkaline carbonate. In this way, as in various types of smoke helmet, the same air, purified and re-oxygenated, is used over and over again. The total weight of the whole outfit is 16 lb. Folded up for stowage it occupies a space of 12in. by 12in. by 15in. The dress can be put on without assistance in 30 seconds. When on it prevents a man from drowning, and in proof of this it may be said that it is now in everyday use under water with perfect success. Another important attri-

bute is that it acts as a lifebuoy and actually raises its wearer to the surface. An additional device is also fitted to enable the wearer when he reaches the surface to inflate a flexible chamber which surrounds the jacket and thus to form a lifebelt. This provision is necessary, for the length of time the purifier will remain in action is limited, and when its efficacy is impaired the door in the helmet must be opened, which operation can be performed by the wearer—in order to admit fresh air. When this is done the helmet ceases to be buoyant. In Fig. 4 the buoyant chamber is shown at C; B is the pipe leading from the helmet, A a valve, and D the mouthpiece inside the helmet into which the wearer can blow. Other methods, such as the fitting of cork belts or chambers already filled with air, have been tried and abandoned, being found to be impracticable, owing to the necessity of employing heavy weights to keep the wearer down, and

Fig. 6—EMERGING THROUGH HATCH OF CONNING TOWER

also by reason of the dangerous velocity with which he would rise to the surface on the removal of the weights.

It is claimed, and with reason, that a great point in favour of the apparatus is that it can be exercised in. The man is made accustomed to put it on—see Fig. 1—and to work with it under water as a matter of ordinary routine. At Portsmouth the Admiralty have in use a huge water tank, at the bottom of which is erected a skeleton submarine boat. At the surface there is fitted an arrangement for lowering and raising the air lock—see Figs. 2 and 3. The men having first been trained to put on the dress quickly are set to practise getting into and out of the air lock. They are afterwards lowered in the air lock to the bottom of the tank—see Fig. 5—where they enter the submarine, and find their way to a ladder leading to the conning tower, the hatch of which they open—see Fig. 6. In the case of this engraving the water in the tank was partially lowered for the purpose of taking the photograph. They then either float to the surface or return to the starting point, the operations being repeated until the officer in charge considers the men proficient. These arrangements have been designed to represent as nearly as possible the same conditions as would obtain in a submarine boat that had been flooded.

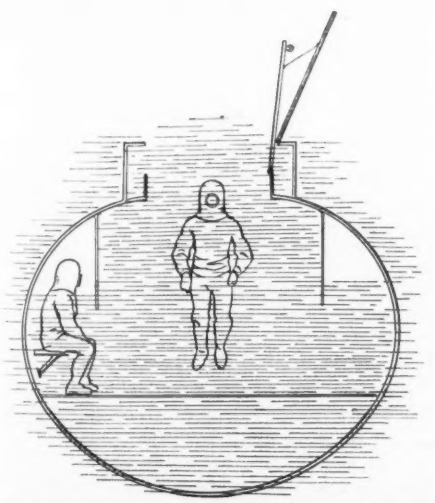


Fig. 7—FLOATING UP THROUGH TORPEDO HATCH

If, as has been explained above, the hole made in the submarine be at the top, the water will gradually displace the whole of the air. If, however, the hole is below the top, then the water will only enter until the air, which cannot escape, has been compressed until its pressure is equal to that of the water outside. In the latter case there is no difficulty in getting at and putting on the helmet dress, since there is air inside the hull. In the former case, however, unless some special provision were made, this would not be so, and, accordingly, bulkheads are arranged as shown in Fig. 7—so as to trap the air. The dresses are kept hanging up in readiness in the air pockets so formed. This does not in any way affect the habitability or efficiency of the vessel, and all the newer submarines in the British Navy are so fitted, whilst the older types are being converted.

It is claimed, further, that the apparatus makes an excellent shallow water diving dress, though in this case the man has to be weighted, and that it is also efficient as a smoke helmet. As a diving dress it can be used for about forty minutes at a maximum depth of 25ft. on one charge of the oxygen-producing compound. As a smoke helmet the densest and most sulphurous fumes can be encountered with immunity, and the man can do light work for about one hour or hard work for about forty minutes on one charge.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

THE GAS PUMP.

SIR,—Mr. Humphrey's mind appears very much disturbed because I said his pump should have a pipe of a capacity something like that which his actual pump has.

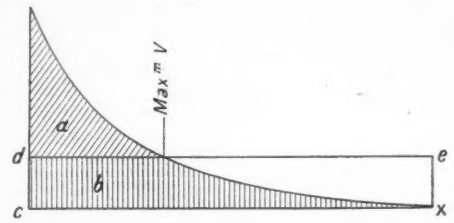
From Dr. Unwin's report of the pump I find that the pipe is 24in. diameter and 135ft. long. The lift is 33ft., so that the pipe is four times the length of the lift.

Mr. Humphrey, in his letter to you, says that he only requires a pipe of one-tenth the length. Then why in the name of common sense did he take the trouble to go out into the wilderness with a pipe 135ft. long, involving a return pipe of equal length when the tank into which the water was pumped was immediately by the side of the pump itself? Why did not the pump deliver direct into the tank? The reason is quite obvious. Without a pipe of similar capacity to that of the one used, there would not be kinetic energy enough in the water to enable the gases in the pump to be expanded from the initial to atmospheric pressure, with a reasonable amount of effective work. If the 24in. pipe had been reduced to a length of 33ft. the capacity of the pump would have been reduced to about one-fourth the power, the other conditions remaining the same.

Mr. Humphrey accuses me of propounding a theory to the effect that the length of the pipe must be three to four times the length of the vertical lift, where the maximum velocity of the water is limited to 10ft. per second, and omits to say that my statement was conditional on the pipe being the same size as the rising main. I propounded no theory that it must be so, but I know of a practical reason why it should be so. It should be so if you wish to get a reasonable quantity of water through a given size pipe at a given head.

If anyone were to tell me that a fly-wheel of a given weight and speed was as effective on a large gas engine as on a small one I should reply, "Tell that to the marines." The Humphrey pump is a pistonless gas engine in which the water in the pump pipe performs the function of a fly-wheel. The larger the capacity of the pipe the heavier the fly-wheel.

If we had an indicator diagram from the pump, it would be easy to discover what weight of fly-wheel was required for a given speed. We have no diagram from the Humphrey pump, but it is not difficult to imagine what it must be like if it has any analogy to a gas engine diagram. It would probably be like the following figure:—



The area *a* represents the energy taken up by the water in the pipe, and the area *b* the direct-pressure energy; the two areas together being equal to the work done, or the area of the rectangle *c*, *d*, *e*, *x*. The area *a* would probably be about four-tenths, and the area *b* six-tenths of the rectangle.

A 24in. pipe has a capacity of about 20 gallons, or 200 lb. of water per foot run. The energy of 200 lb. at 10ft. per second equals $\frac{W\ V^2}{64} = 300$ foot-pounds.

Example is better than theory. Take a 24in. pipe; pump displacement during the forward stroke, 250 gallons; 200ft. lift; and maximum velocity of the water in the pump pipe 10ft. per second. The total energy per stroke would then be 200ft. lift multiplied by 2500 lb. pump displacement, equal to 500,000 foot-pounds. Four-tenths of that energy is required to act as a fly-wheel, viz., 200,000 foot-pounds. The length of pump pipe required will then be $\frac{200,000}{300} = 666$ft.

If Mr. Humphrey is going to use a 24in. pipe only one-tenth the length, then the pump will only pump one-tenth the quantity, an absurdly small quantity for a 24in. main.

I stated that the pipe might be shortened by increasing its capacity. If Mr. Humphrey means that his shortened pipe of one-tenth the length shall have the capacity of the longer pipe, then his criticism of my statement is misleading.

The subject will be of more practical interest when Mr. Humphrey has other pumps than the one at Dudley—which has a pipe four times the length of the lift—to refer to. In the meantime I wish him every success. I have a great admiration for the Humphrey pump, and I would have said so at the meeting, and nothing else, but I was under the impression that the paper was submitted for criticism and discussion, and not for eulogy only.

Ewell, December 3rd. HENRY DAVEY.

SIR,—I thank you for your courtesy in submitting Mr. Henry Davey's letter to me, as I am thus enabled to deal with it at once.

Mr. Davey, in opening the discussion on my paper, stated as a definite principle that, if the maximum velocity of the water in the pipe did not exceed 10ft. or 12ft. per second, the horizontal portion of the discharge pipe of my pump would have to be three or four times the vertical portion, assuming the same diameter of main throughout. I replied that the statement was inaccurate, and I now find that Mr. Davey abandons his position.

Again, I pointed out last Friday that as the simple form of Humphrey pump could only lift to 35ft. or 40ft. head, any calculation for a 200ft. lift must refer to the pump worked in conjunction with air vessels, in which case the length of the pipe was independent of the head, but Mr. Davey still ignores this fact.

Now let us turn to Mr. Davey's calculations. His arguments will not be affected if we change the number of gallons delivered per stroke, so we will substitute 75 gallons for his 250 gallons. Following through the calculation with everything else unchanged, the length of pipe works out to 200ft. Therefore, according to his formula, a pump should deliver 75 gallons per stroke to 200ft. through a 200ft. pipe, or, in other words, through a vertical pipe. The horse-power would be considerable, as the operation would be very rapid.

The *reductio ad absurdum* is reached by substituting 37.5 gallons per stroke, for then we find that, the maximum velocity still remaining 10ft. per second, a pump delivering this quantity per cycle to a height of 200ft. would only require 100ft. of pipe al told.

Mr. Davey asks a number of questions. I will reply as briefly as possible. The arrangements at Dudley Port had to be such that the pump could be tested at various heads. To arrange tanks for this would have been very expensive, while an air vessel was relatively cheap, and admitted of the head being changed instantly. Then as regards the 135ft. of pipe used with the pump tested by Dr. Unwin, this pump was at first run with 63ft. of pipe, but at the highest lift, and with the water valve area available, the longer pipe gave the best efficiency. For a given lift, charge volume, and diameter of pipe the horse-power increases as the length of pipe diminishes, so long as sufficient time is allowed for the water to enter the pump, and this is where Mr. Davey makes another mistake, as he states the contrary. The shorter pipe gives the greater number of cycles in unit time.

Genuine criticism is always welcome and helpful, eulogy is not wanted, but inaccurate statements must be corrected. Mr. Davey and I have since met, and I am sure the heartiness of handshake was genuine on both sides, so I trust the matter may now drop, as we are both too busy to indulge in paper warfare, and the space in your columns is too precious. H. A. HUMPHREY.

London, S.W.,
December 8th.

SIR,—Replying to Mr. Humphrey's letter in your issue of the 3rd, it would be superfluous to point out to him that it is not only usual, but advisable, in giving a guaranteed fuel consumption, to name a figure that one knows can be easily achieved, so as to allow for the unavoidable fluctuations in the quality of producer gas, and for the differences in the calorific values of different fuels. The margin of .11 between "water horse-power" and "brake horse-power" does not seem to me to err on the side of excessive caution. Personally, I am a believer in the "Humphrey" pump, and fully recognise that it may not yet have reached its highest efficiency in the tests which have been made, and it was only to advocate the claim—possibly temporary only—of the gas engine, that I wrote my last letter. I am pleased to include Mr. Humphrey among my personal friends, and it was for this reason, and with a wish to avoid any appearance of "trade controversy," that I wrote my letter in my private capacity.

The Wyelands, Buxton, S. HASTINGS IRWIN.
7th December.

CENTRIFUGAL FORCE.

SIR,—I have read from week to week the various replies which your kind correspondents have given to my question, and this morning I have sat down and read them all over again. The effect of the whole correspondence on my mind is that centrifugal force presents a dilemma which no one has been able so far to solve.

It is interesting to note that not one of your correspondents has said that another correspondent is right. On the contrary, from the mass of words, so far as anything bearing on this point can be gathered, it appears to me that there is no formal agreement whatever, while there is a good deal of contradiction. It would help matters perhaps if, for example, Mr. Sayers would tell me whether he agrees with "Lundin," or if Mr. Dines would say whether he is in accord with "A. R." or with "L. R."

The dilemma has more horns than two. I will take two. First we are told that a revolving constrained body is continuously "accelerated" toward the centre round which it revolves. The popular definition of "accelerated" is "hastened." A falling body is accelerated by gravity, its velocity becoming continuously greater and greater. Turning to "Nuttall's Standard Dictionary," I find "accelerate, *v.t.* to hasten; to quicken the speed or rate of (L. *ad* to and *Celer* swift").

"Accelerated, *a*, quickened in motion, hastened in progress; *accelerated motion*, that which is continuously receiving fresh accession of velocity; *accelerated force*, the increased force which a body exerts in consequence of the acceleration of motion."

"*Acceleration of the moon*, her increase of mean motion compared with the diurnal motion of the earth."

Your correspondent "X." mentioned Clark Maxwell. In the little primer, "Matter and Motion," I find, "the word acceleration is here used to denote any change in the velocity, whether that change be an increase, a diminution, or a change of direction. . . . As the displacement of a system is defined to be the change of the configuration of the system, so the Total Acceleration of the system is defined to be change of the velocities of the system." This seems definite enough. Until we come to curvilinear motion, indeed, there is no other definition or meaning given to the word acceleration save hastening.

Secondly, it is a definite proposition—an axiom, indeed—that no change in direction or velocity of movement can be produced without the action of some external force; and it is further defined that the operation of a force through a distance means work.

What your correspondents have tried to do for my benefit is to reconcile these propositions with the explanations (?) of centrifugal force contained in text-books. In the first place, as a fact, the velocity of the stone is constant. There is no acceleration; consequently there is no work done. We are, however, told that the stone is continuously accelerated, and that it is the production of this acceleration that causes the radial pull. Here, then, we have a mass accelerated by a force, and yet no work is done. This seems to me to be a hopeless muddle of definitions. In order to get out of it we are told that for this particular case—so far I have been unable to find any other—a special meaning is given to the word acceleration. Precisely what this meaning is no one appears to know. According to Sir Oliver Lodge, as quoted by your correspondent X. it seem to be something which the stone is constantly receiving and never gets, which reads more like a "bull" than a scientific explanation of ascertained facts.

Nobody, of course, knows why there is a tangential effort. I am told that the first mathematician to investigate centrifugal force was the Marquis de l'Hopital. He seems to have been responsible for the statement that when a body is constrained to move in a circle it will make that circle as large as possible, because a large circle diverges less from a straight line than a small circle, and in any given advance of the body it is, therefore, less deflected.

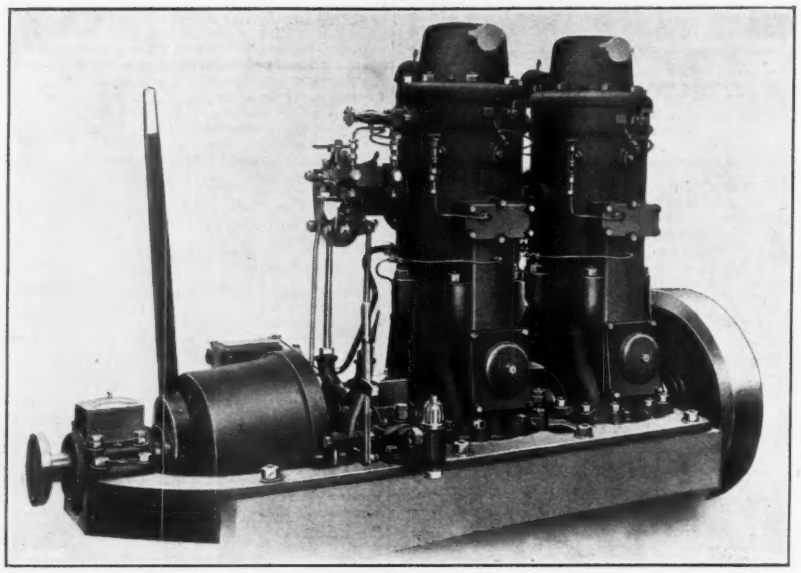
Incidentally, I may point out that the diagram given by "L. R." possesses the merit of originality. Nothing of the kind is, I am sure, to be found in text-books, according to which, while the stone is revolving, there is no force in operation but a tangential force. The line M F L has no existence. The diameter of the circle T P is quite arbitrary. Why not make it equal to that of the circle described by M?

The general result of an examination of the whole matter appears to me to be that the scientific men who write text-books have failed to find words to express their meaning, or to build up concepts on the virgin soil of the student mind—perhaps I may be excused this mixed metaphor. Examples of this crop up everywhere about the question. Thus, while the string pulls on the stone and the stone on the string, we are told that the result is a "stress" and that a stress does no work. If, now, the stone lies in a little carriage which runs without friction on a perfectly smooth level table, precisely the same pull will really accelerate the stone in the car and will do work upon it. In this case, then, a stress does work. Perhaps it is not a stress. Will any correspondent kindly say if not, why not, and what is the difference between a stress and a balanced force, and let us have a definition of an unbalanced force?

Might I suggest that some competent authority shall frame an accurate concept of what centrifugal action really is, and then select with care words which will involve no contradiction and will serve to transfer that concept to the mind of a student and

December 4th. PATER.

A REVERSIBLE MARINE OIL ENGINE



A NEW REVERSIBLE MARINE OIL ENGINE.

AT the invitation of James Pollock, Sons and Co., of 3, Lloyd's-avenue, E.C., we were recently invited to attend a demonstration which was organised to show the capabilities of the Bolinders direct reversible marine oil engine, fitted to a bluff-built fishing vessel of the Swedish type, 60ft. by 19ft. by 9ft. A short trip was made on the Thames, when the engine was reversed with great ease, and the general manipulation was equally satisfactory. The engine, which is shown above, is of the two-cycle type, delivering a power impulse for each revolution of the fly-wheel. The principle will be understood from the diagram—Fig. 1. On the upstroke of the piston a partial vacuum is created in the enclosed crank chamber, causing the charge of air to enter at the inlets B. When the piston is near the end of the stroke, an oil pump automatically injects the proper amount of oil through the nozzle F into the heated ball E. On starting, the latter is heated by means of a blow lamp, but when the engine has been running for a few minutes this is put out of action. The mixture of air and gas is fired, driving the piston downward, during which time the charge of air previously drawn into the crank-case is compressed. When the piston approaches the end of the down-stroke it uncovers the exhaust, the exhaust port G permitting the burnt charge to escape through the silencer. Immediately afterwards the transfer port H on the opposite side of the cylinder is uncovered by the piston, thereby allowing the charge of air compressed in the crank chamber to pass into the cylinder, where it is deflected upwards by the shape of the top of the piston, and caused to fill the cylinder, thereby expelling the remainder of the burnt charge. It will be seen that the engine is of very simple construction. The method of reversing the engine will be understood from the diagram—Fig. 2. A is an oil-fuel pump, having two pistons B C. The piston B is adapted to work during normal conditions when the engine is running in one direction, while the other C is used for reversing. Suppose the engine to be running in the direction of the arrow, then during the normal running of the engine the feeding mechanism appertaining to the pump piston B is in action. It is worked by means of the excentric D, which imparts to the lever E a rocking motion, by which the weight F is reciprocated on the arm H.

The feeding mechanism for reversal is of the same construction, and acts in the same manner as that for normal running. The reversal of the direction of movement of the engine takes place in the following manner:—The lever G is thrown to the right, so that the left edge of the link K is thrown into engagement with the friction disc L, whereby the link and rod S are lifted. The arm H is lifted from the abutment O, and at the same time the arm P is moved from the position illustrated toward the abutment R. The result of the shifting of the two arms H and P is first of all to raise the weight F, so that its tooth T cannot strike the piston B, and, secondly, that the weight U takes up such a position as to be able to strike the pump piston C. The feeding mechanism working during normal running is thus thrown out of action, and the feeding mechanism used for reversing is thrown into action. That one mechanism works for normal running in either direction and the other for reversal will be evident on considering that the weights F and U in one and the same position of the engine take up opposite end positions. When the weight F is in the position in which it keeps the piston B pressed inwardly, the working piston of the engine is at that end of the cylinder next to the explosion chamber, whence it will be driven out by the explosion of the fuel just injected. When the piston has arrived at the other end of the cylinder, the main shaft has made half a revolution, and the weight U is thus in the position in which it will press the pump piston C inwardly, provided, of course, that the reversing handle has moved so as to reverse the engine. Assuming this to be the case, the pump piston C feeds fuel into the cylinder. The fuel consequently explodes before the working piston has reached its innermost position. The piston is thus stopped, driven backwards, and the engine begins to move in the opposite direction. After the lever G has been shifted towards the right and the engine has commenced to rotate in the opposite direction, the link K with the rod S are obviously moved downward. On account of this, the arms H and P are automatically shifted so that the weight F is again made operative instead of the weight U. The explosions therefore again take place at the normal time, so that the engine is continually driven in the direction obtained after reversal. If the engine is to be reversed again, the lever G is thrown to the left, so that the edge of the link K is again brought into engagement with the friction discs. At X and J there are two springs to keep the weights F and U in contact with the moving arms. As will be seen from our illustration, the engine fitted to the boat mentioned above has two cylinders. The diameter of the cylinders is 330 mm. and the stroke 340 mm. The speed is 325 revolutions per minute. The engine has several special features in addition to the reversing gear, one of these being that no separate compressor is used for compressing the air for starting purposes, one of the engine cylinders serving this purpose. The capacity of the engine, which we have recently had an opportunity of inspecting, is 80 horse-power, and it is capable of developing 20 per cent. overload. The engine has a pump for providing water circulation and also a bilge pump. Forced lubrication is used throughout, and all the principal bearings have a small pump driven from a common shaft. In this particular boat the whole of the control is carried out in the engine-room, but the firm is now constructing a 70ft. motor barge which is to be controlled from the deck. This is also to be fitted with an 80 horse-power engine of the same type.

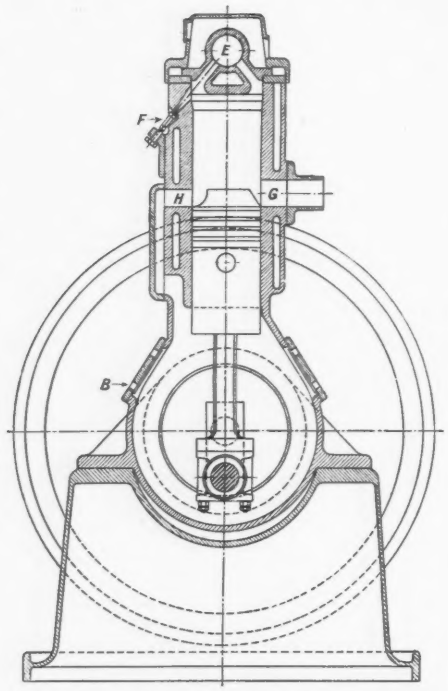


Fig. 1—VERTICAL CROSS SECTION OF THE ENGINE

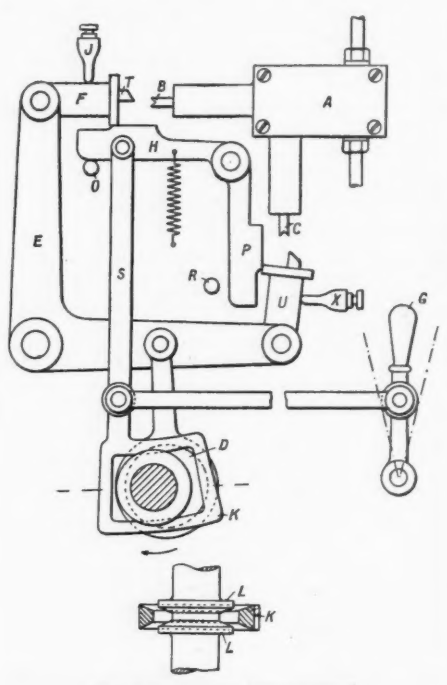


Fig. 2—REVERSING MECHANISM

SHIPBUILDING NOTES.

THE new work contracted for during the latter part of last month has gone mainly to the Clyde. In addition to the three large vessels for Messrs. H. and W. Nelson's South American trade which have been already noticed, Messrs. Russell are to build a cargo steamer for Glasgow owners. Messrs. Hamilton, of Port Glasgow, have contracted to build one, and Messrs. McMillan, of Dumbarton, two cargo steamers. It is also stated that Messrs. Barclay, Curle and Co. have secured the contract for a large steamer for the Blue Anchor line. On the other hand, Messrs. Denny Bros., who are usually fortunate in respect of their winter's provision of orders, are on short time, the men working an eight hours' day.

IT is stated that the Admiralty order for the two floating docks intended to accommodate the latest battleships of the improved Dreadnought class has now been placed. The successful firms are Messrs. Swan, Hunter and Wigham Richardson and Messrs. Cammell, Laird and Co. As our readers know, these are to be the largest docks of this kind yet built; the total lifting capacity is to be 32,000 tons.

WE regret to have to record the death of one who was well known in the shipbuilding world, Mr. W. J. Bone, managing director of the Tyne Iron Shipbuilding Company, Limited. Mr. Bone, who was in his sixty-seventh year, was trained in the service, and studied at the Royal School of Naval Architecture, and, as an old student of that school, he was generally seen at the biennial dinners of old students. He was for a long time a surveyor to Lloyd's Register, and was one of the original partners of the Tyne Iron Company.

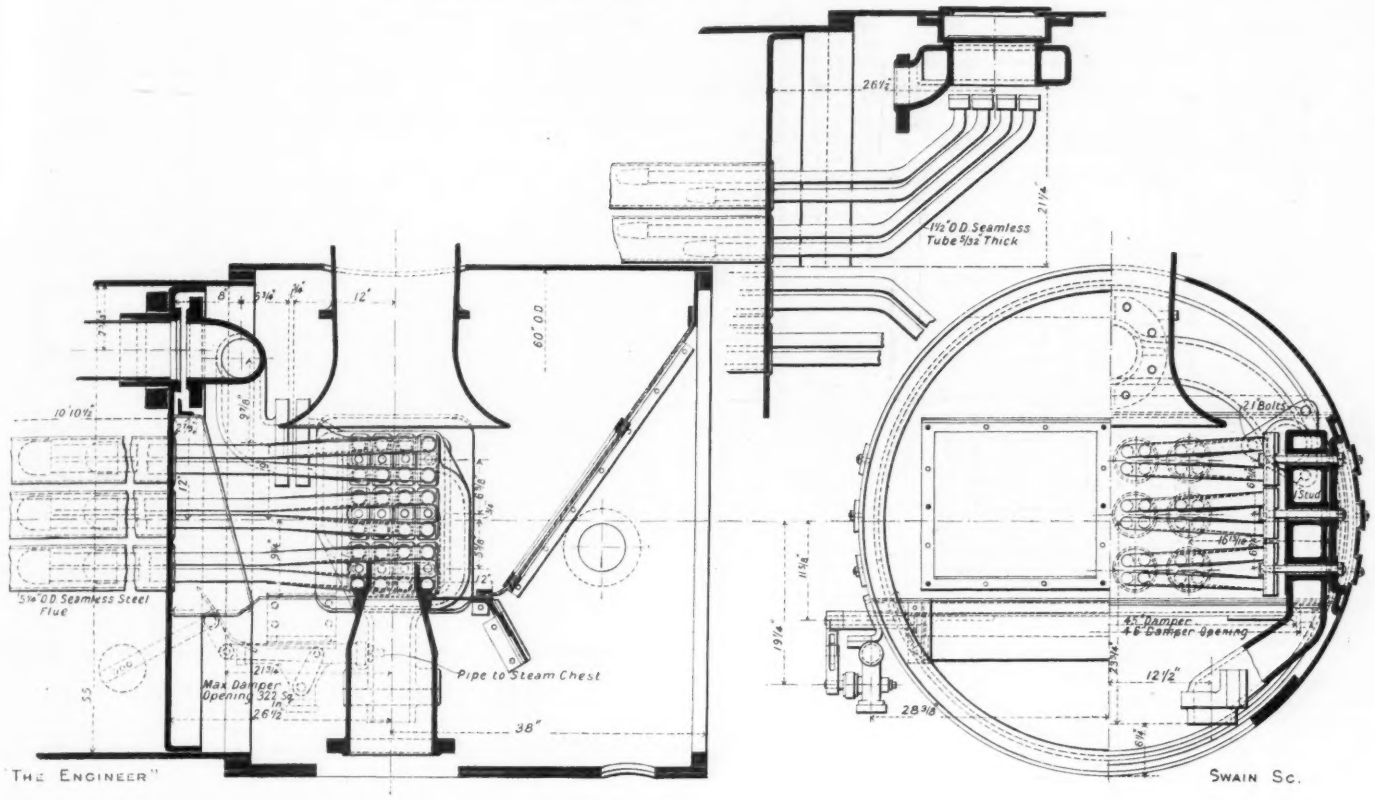
THE report of the United States Commission of Navigation contains some points of interest. Dealing with the annual period ending with June of this year, it is reported that the total commercial shipping of the United States has reached a total of 25,688 vessels, representing 7.4 million tons—a larger total than that credited to any other country except Great Britain. It is significant to note, however, that a very great proportion of the above tonnage is engaged in domestic trade only, and that only 887,000 tons are registered as being for oversea commerce. This total is less than that of the preceding year by 53,000 tons, and, in addition, it is stated that a goodly proportion even of this small tonnage is idle. The report shows that the depression, with which we are unhappily familiar, is not local, but practically of world-wide scope. At the same time, it is rather surprising to find so small a part of America's mercantile marine engaged in foreign trade. In the summer of this year there was a considerable activity in American shipbuilding, and a few vessels were then laid down in Atlantic coast yards for oversea freight purposes.

AS we have before remarked, the literature of naval architecture is, considering the importance of the subject, very meagre in respect of quantity at least. This fault is being slowly remedied, and some time ago Professor Biles published the first volume of his long promised work on naval architecture. Professor Biles, of course, addresses himself to readers who have already received some instruction in the subject, and we are glad, therefore, to welcome a new volume, intended for the average student, by Mr. Nicol, a member of the Institution of Naval Architects. Mr. Nicol appears to have the faculty for laborious collection of facts, and to have also the capacity to set forth these facts in a straightforward and clear manner. The book—"Ship Construction and Calculations"—covers very completely the elementary part of the subject, and should prove useful to officers, draughtsmen, &c., for whom it has been written.

FOR the Hoogli service of the Bengal-Nagpur Railway Company there was launched on November 28th from the yard of Wm. Denny and Brothers, Dumbarton, the train-ferry steamer Sir Trevredyn Wynne, 300ft. long, 50ft. breadth moulded, and 11ft. 6in. deep at sides. This vessel is to carry on her deck three heavily loaded goods trains, and at each end there is a set of three turntables worked by steam and controlled from the deck. Care has been taken to provide strength against racking as well as against longitudinal strains. The vessel is of the same design at each end, and all gear is duplicated, so that she may run either ahead or astern. The propelling machinery consists of two independent sets of paddle engines, which, together with the boilers, have been designed to come entirely underneath the main deck. The vessel has been built to the specification and instructions of Sir John Wolfe Barry, K.C.B. The train ferry service on the Hoogli, when started eight or nine years ago, was very strongly opposed. It has proved so successful that the port authority granted permission to duplicate it.

LOCOMOTIVE SUPERHEATER

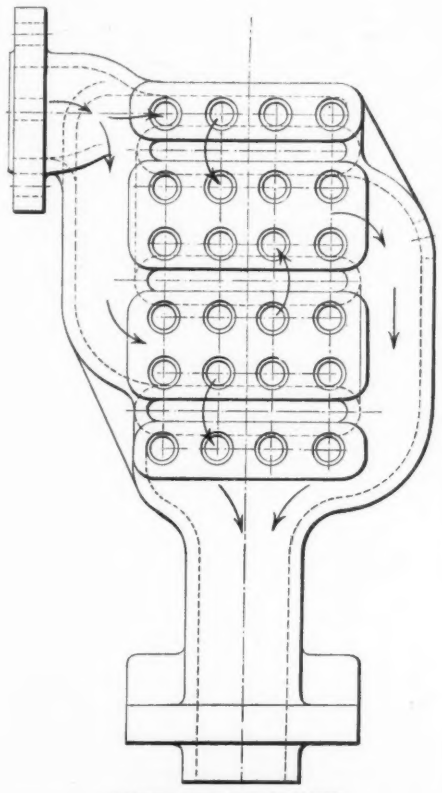
THE AMERICAN LOCOMOTIVE CO., SCHENECTADY, ENGINEERS



AN AMERICAN LOCOMOTIVE SUPERHEATER.

THE application of superheated steam to locomotives has for many years past received particular attention at the hands of American engineers, and in the example of an apparatus of this kind, which is herewith illustrated, there will be found several features of interest, since it may be taken as embodying the most recent ideas on this subject.

The engines to which this superheater has been fitted are two eight-wheeled passenger locomotives built by the American Locomotive Company for the Western Railway of Havana. A previous example of this form of superheater is



HEADER FOR SUPERHEATER

to be found on a "Consolidation" locomotive recently built by the same company for the Wabash-Pittsburgh Terminal Railway. From the engraving, showing the smoke-box details, it will be seen that the superheater is of the return-tube type. On either side of the smoke-box barrel a cast iron header is bolted to a box-shaped casting. The interior of these headers is divided by walls into four distinct chambers—see end view—and of these, reckoning from the top, the first and third are in communication with the steam tee-pipe, while the second and fourth are connected to the steam passage of the cylinder, the connecting pipe being formed as part of the header, thereby avoiding unnecessary joints. Six rows of holes are formed on the inner face of the header, the first and fourth chambers having one row each, and the second and third, two. From these holes pipes are led, and being suitably bent, these enter the enlarged boiler tubes provided for their reception. Four tubes from the header are led into each boiler tube, and extend back to within 32in. of the fire-box tube plate, where they are connected vertically by return bends into pairs. It will thus be seen that steam supplied to the first and third chambers will leave the header by the first, fourth, and fifth rows of tubes, travel back towards the fire-box, and return to the header by the second, third, and sixth rows, which lead, as already stated, into the second and fourth chambers, and thence to the cylinder.

The peculiar method of securing the superheater tubes to the header is worthy of special note. For this purpose the ends of the tubes are upset, machined to a spherical form, and ground into their seats, which consist of the countersunk edges of the holes in the header. A gland extends across the ends of each connected pair of tubes, and a single bolt in each gland serves to pull the tubes tightly on to their seats. Provision is made for the passage of these bolts through the header by leaving an open space between the four chambers above mentioned. The bolts pierce the box-shaped casting attached to the side of the smoke-box, and are secured by nuts to which access is had through doors provided for that purpose in the smoke-box barrel plate.

It is claimed by the makers, who are also the patentees of the superheater, that this design allows complete freedom for expansion and contraction, and hence avoids the troubles incidental to leaking joints which are features of some other arrangements.

To control the admission of the hot gases to the large boiler tubes, a damper is provided at the smoke-box end. The arrangement of this damper is clearly shown in the engraving. A small steam cylinder in communication with the steam chest of the main cylinders is carried on the platform outside the smoke-box, and this cylinder operates the damper automatically, a balance weight being provided to give the return or closing motion. It will thus be seen that admission of steam to the cylinders also involves the opening of the damper, and brings the superheater into action, which at other times is inoperative.

We give below some numerical data dealing with the engines and superheater :—

Cylinders	18½in. by 24in.
Driving wheels	68in. diameter
Working pressure	165 lb.
Tractive effort	17,000 lb.
Grate area	17.8 square feet
Heating surface (tubes and fire-box)	1071 square feet
Heating surface (superheater)	153 square feet
Tubes :—	
135 charcoal iron	2in. by 12 I.W.G.
43 seamless steel	1½in. diameter
12 seamless steel	5½in. diameter

THE REDUCING ALLOY SICAL.

A REDUCING alloy to which the name of Sical has been given has recently been put upon the market by the Société des Carbures Metalliques, the works of which are at Notre Dame de Briançon in France, whilst the London representative is Monsieur A. P. Champin, 47, Victoria-street, Westminster, S.W. This alloy consists principally of a mixture of silicon and aluminium with the addition of small quantities of other elements, such as titanium, calcium and manganese. It is claimed that it is suitable for all steel and iron metallurgical processes, and particularly so for cast and rail steels. It contains the ingredients mentioned in approximately the following proportions :—

	Per cent.
Silicon	50 to 55
Aluminium	22 to 29
Titanium	2 to 4
Calcium	1
Manganese	0.20
Carbon	0.20 to 0.30

Its introducers state that it can :—(1) Entirely take the place of ferro-silicon, which is now so universally used, even when added in smaller proportions than are usual with this substance; (2) turn white pig iron into grey pig iron when put without modification into the cupola; (3) absolutely prevent blow-holes or flaws during the manufacture of steel, its special effect being to disperse the gases in the metal by carrying them away together with the fluid scoriæ. And that, further, the metal obtained is harder and the melting operation less violent, while all the iron oxides are reduced on account of the greater affinity of silicon for oxygen. It is urged that ferro-silicon alone, only acts as it does by reason of the presence of silicon, which is combined with iron during its manufacture for the convenience of the operation, that the combined iron is a deadweight and is unremunerative, and that the substance reduces the temperature when tapping at the very moment when the maximum fluidity is important. It is further urged that aluminium, which acts upon steel more energetically than silicon, has, when used alone, the objections of being high in price and of being very volatile, thus showing a heavy proportional loss on melting.

On the other hand, it is stated that all the elements of the Sical alloy act at the same time, and that its peculiar qualities are due to the proportions of each element present. It is but slightly volatile, and it will not begin to volatilise till a temperature of 1350 deg. Cent., 2462 deg. Fah., is reached.

We have not had an opportunity of observing for ourselves the action of this alloy and are only able to add to the foregoing the following statements regarding its action and attributes which have been furnished to us by the makers. Its use with cast iron is advantageous as this material contracts strongly in cooling, and while hot has a tendency to absorb gases. Sical, being low in carbon, prevents flaws during cooling. It will find its most general application in Martin furnaces and small converters. The scoria which remains is a silicate of alumina and lime. It is readily fusible, and when floating after tapping removes the impurities and gases, if any are still present, and the steel obtained is homogeneous and tenacious. Steel and iron castings of all kinds can be perfectly made when it is used.

The following statement of the relative calorific value of Sical and other alloys has been handed to us by the makers :—

	Calories.
1 lb. of ferro-silicon 25 per cent. Si gives for its contents of Si	886
1 lb. of ferro-silicon 50 per cent. Si gives for its contents of Si	1773
1 lb. of silico-calcium 63 per cent. Si and 28 per cent. Ca gives for its contents of Si and Ca	2650
1 lb. of ferro-silicon 75 per cent. Si gives for its contents of Si	2650
1 lb. of Sical 55 per cent. Si and 25 per cent. Al gives for its contents of Si and Al	1900
1 lb. of pure carbon, it may be added, gives over 3900 calories.	

THE use of T-rails is recommended for track construction in paved streets by the committee on permanent way matters of the American Street and Inter-urban Railway Engineering Association, except where the traffic is confined to the railway strip, or is so congested that the strip is continually used by vehicles. Under these conditions, which obtain only in the largest cities, the committee recommended a girder rail with a deep, roomy, self-cleaning groove.

THE INSTITUTION OF MECHANICAL ENGINEERS—AN INTERNAL COMBUSTION PUMP

(For description see page 617)

Fig 11.

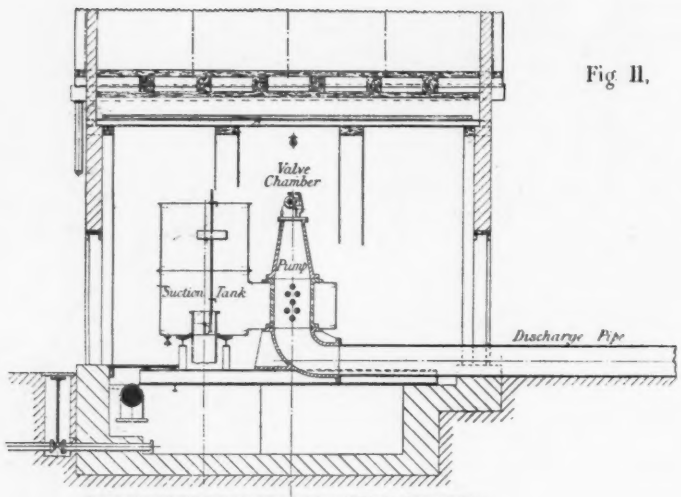
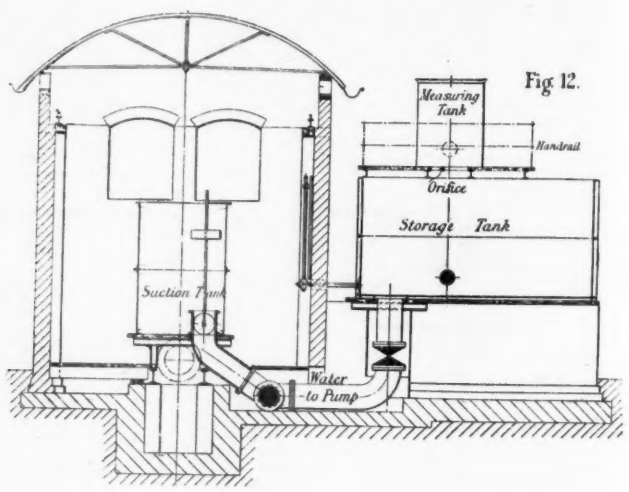


Fig 12.



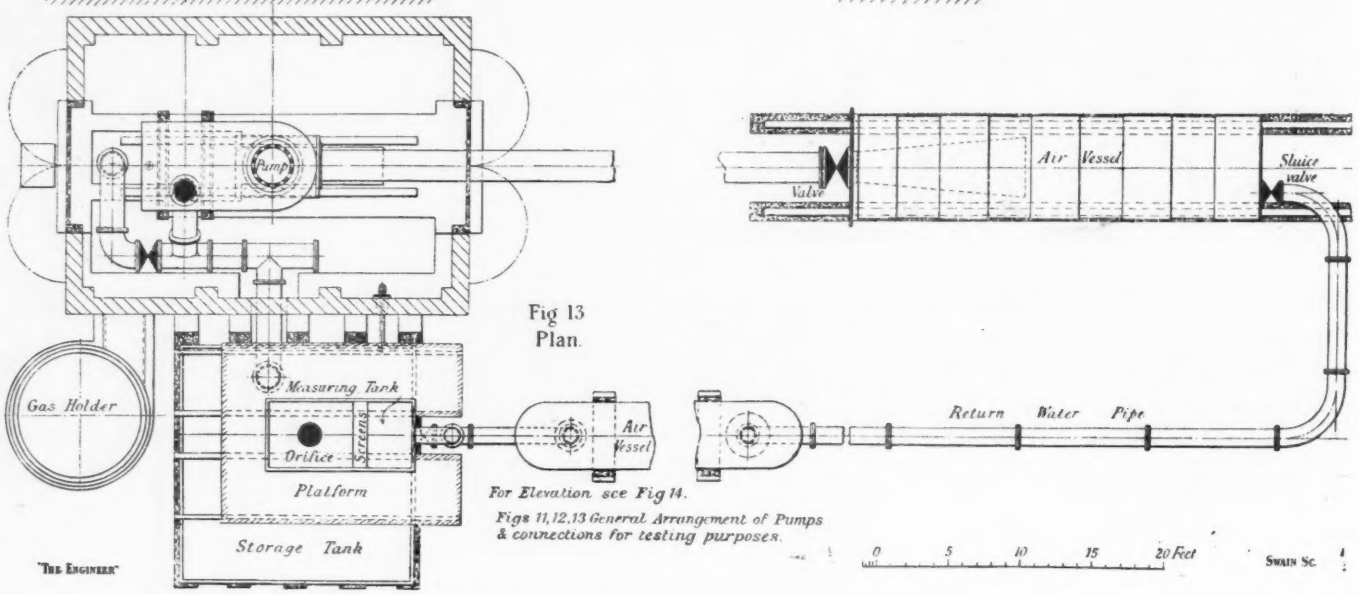


Fig 13
Plan.

For Elevation see Fig 14.

Figs 11, 12, 13 General Arrangement of Pumps & connections for testing purposes.

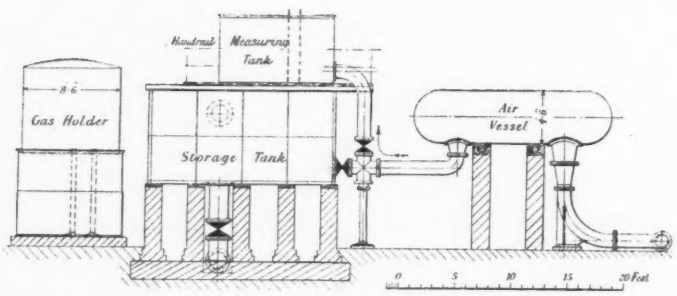


Fig. 14.—*Tanks for Testing.* (For plan see Fig. 13.)

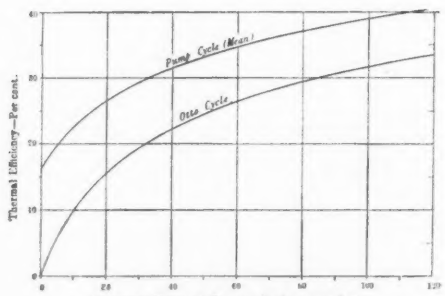


Fig. 17.—*Practical Efficiency Curve.* 0·71 *of Air Standard.*

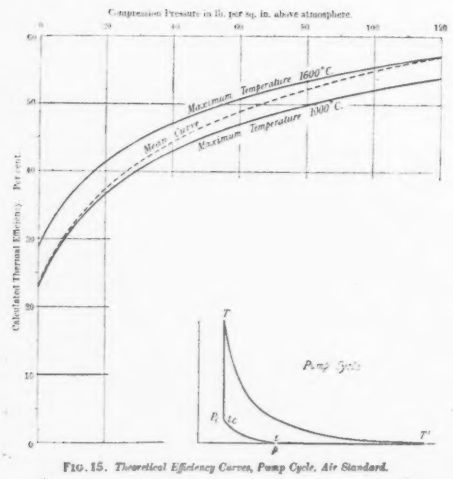

Compression Pressure in lb. per sq. in. above atmosphere
Maximum Temperature 1600° C.
Mean Curve
Maximum Temperature 1000° C.
Calculated Thermal Efficiency—Per cent.
Pump Cycle

Fig. 15. *Theoretical Efficiency Curves, Pump Cycle, Air Standard.*

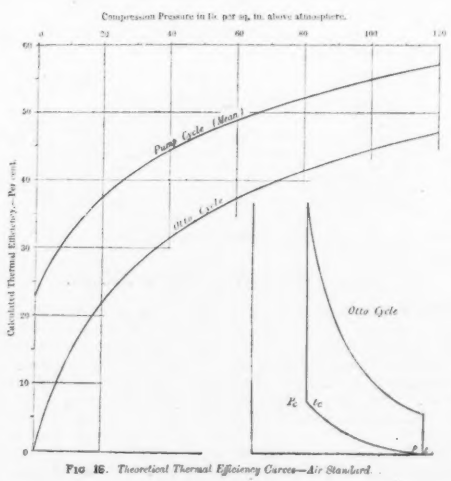

Compression Pressure in lb. per sq. in. above atmosphere
Pump Cycle (Mean)
Otto Cycle
Calculated Thermal Efficiency—Per cent.

Fig 16. *Theoretical Thermal Efficiency Curves—Air Standard.*

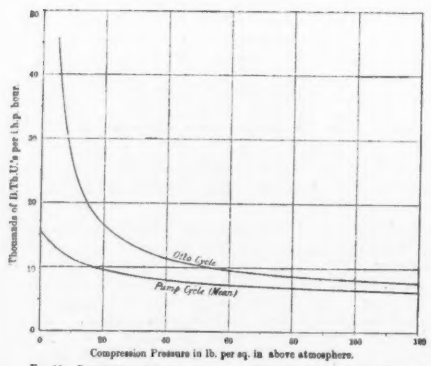


Fig. 18.—*British Thermal Units per i.h.p hour. Calculated from* 0·71 *of Air Standard.*

AN INTERNAL COMBUSTION PUMP, AND OTHER APPLICATIONS OF A NEW PRINCIPLE.*

By MR. HERBERT A. HUMPHREY, Member, of London.

(*Concluded from page 587.*)

Efficiency tests.—The first experiments were carried out at Brimsdown, but in the early part of 1908 a testing station, specially designed to facilitate the testing of the pumps, was erected on ground belonging to the South Staffordshire Mond Gas Company at Dudley Port. Mond producer gas, electric current, compressed air, and a good supply of water, were all available at the site chosen, and the plant erected by the Pump and Power Company which controls the author's patents, is illustrated in Figs. 11 to 14 The building for containing the pump is fitted with an overhead

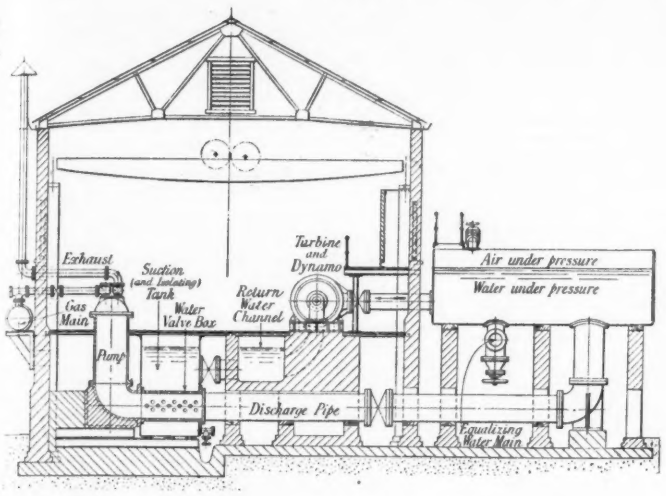


FIG. 19. *Diagram of suggested Central Electric Station, showing Hydraulic Coupling between the Gas Power and Electric Power.*

crane for lifting off the cylinder cover of the pump and demonstrating how quickly the few working parts can be changed. The pump itself is shown, and the delivery main passes into an air vessel upon which any pressure can be put by means of compressed air. The outlet from the air vessel is connected to the measuring tank, which contains perforated baffle plates to stop eddy currents, and in the bottom of the tank is fixed a casting which receives any one of a number of accurately made sharp-edged orifices through which the water flows into the large water stock tank below. An accurately graduated gauge is fixed close to the orifice to show the height of the surface of the water above the sharp edge of the orifice, and when this height and the size of the orifice are known, the quantity of water passing through the measuring tank can be readily ascertained through the well-known formula:—

Gallons per second $= 6.24\ k\ A\ \sqrt{2gH}$.

Where k = coefficient of contraction of orifice.
A = area of orifice in sq. ft.
H = head over orifice in feet.

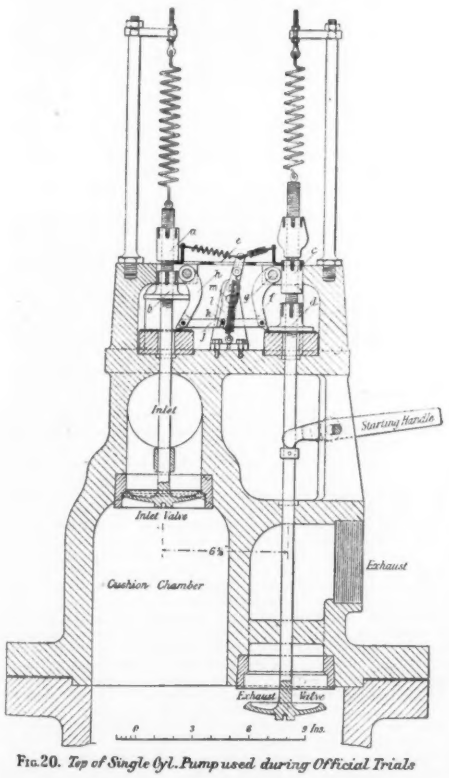


FIG. 20. *Top of Single Cyl. Pump used during Official Trials*

The stock tank is connected by an 18in. pipe to the suction tank of the pump, and thus the water is merely circulated over and over again. Between the air vessel and the measuring tank there is a valve, so that the flow is throttled at this point in order to maintain the required pressure in the air vessel, and pipe connections are brought from the air vessel and the suction tank respectively to the two sides of a U tube containing mercury, so that the actual lift of the water can be measured on a properly graduated scale.

The gas holder for measuring the gas was specially constructed for test purposes. A calorimeter for obtaining the heat value of the gas, and the usual appliances for analysing the gas and burnt products, are included in the equipment. Other testing appliances are referred to more fully in the Appendix.

Many tests of efficiency have been made with the plant described, and an official test of a four cycle Humphrey pump was carried out by Dr. W. Cawthorne Unwin, F.R.S., and his assistant at Dudley Port on 21st and 22nd of September this year. A summary of Dr. Unwin's report is added as an Appendix and the results show that with a pump of only 16 pump horse-power the consumption of anthracite coal is 1.06 lb. per pump horse-power hour. This is about half the coal consumption of the highest class of steam pump, and it is also considerably less than with an ordinary gas engine driving any kind of pump on the same water lift. With slack costing 6s. 9d. per ton delivered into the Mond producers at Dudley Port, the actual cost of slack to yield the 83 cubic feet of gas mentioned in the report per pump horse-power hour is under 0.06d.

Experiments have shown that the pump works extremely well with petrol supplied through a carburetter, and gives about the same thermal efficiency as when working with Mond gas, but the water delivered from the pump is considerably increased. Water-gas has also been tried, with equal success, but so far neither ordinary town gas nor paraffin has been used. Probably ordinary paraffin, in conjunction with a separately heated carburetter, would form a useful working medium for isolated or contractors' pumping plants.

All the experiments so far have been confined to pumps in which an explosion takes place on ignition, but the author has designed a pump in which the combustion takes place at constant pressure.

Thermal efficiency.—It has already been mentioned that theoretically the pump cycle is superior to that of the Otto gas engine or of any other gas engine in which the volume of the expanded products is the same as the original charge volume. In Fig. 15 a curve is drawn showing the theoretical pump cycle efficiency, assuming that the maximum temperature reached on combustion is 1600 deg. Cent. Another curve is drawn assuming the maximum combustion temperature is 1000 deg. Cent. Using Mond gas and low-compression pressures, the second curve more nearly represents the true state of affairs, but as the compression pressure increases the combustion temperature is also increased, and the first curve is approached. Consequently, a curve, drawn as shown in dotted lines between these two curves, and passing from the lower to the higher of them, fairly represents the correct theoretical efficiencies when using producer gas.

This dotted curve has been transferred to Fig. 16, and plotted against it is the efficiency curve for the Otto cycle gas engine, assuming the working medium in both cases to be air. Mr. Dugald Clerk has shown that the possible efficiency which can be realised in commercial gas engines of fairly large size is about 71 per cent. of the air standard, and, assuming that this ratio also holds good for the pump cycle, we arrive at the two curves given in Fig. 17, in which the attainable efficiencies are compared. It will be noted that although the pump cycle curve is always above the Otto cycle curve, the efficiencies of the pump are greatly in excess of those of the Otto engine at low-compression pressures. This is much to the advantage of the pump, because it enables a good commercial efficiency to be obtained with relatively low working pressures.

In Fig. 18 the results of Fig. 17 are translated into British thermal units per indicated horse-power hour, so that with any working medium of a given calorific value it is possible to see how the gas consumption varies with different compression pressures.

Application for power purposes.—The curves just mentioned are specially interesting, because they lead one to recognise the possibility that, as the author's system comes to be developed in the future, internal combustion pumps may be substituted for gas

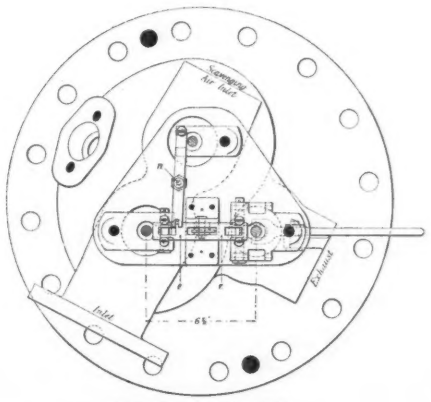


FIG. 21.—*Plan of Cylinder Top, Fig. 20.*

engines in central electric power stations. If the water pumped is passed through an ordinary water turbine driving an electric generator, and the water is then returned to the pump to be used over and over again, we arrive at a gas-power electric system with the water forming a hydraulic coupling. Even now the combination of the author's pumps with water turbines gives far greater economy than that reached by any internal combustion turbine so far constructed. It is, of course, dangerous to prophesy, but there is no harm in looking so far ahead into future possibilities in order to see what a central station on the new lines might be like.

Fig. 19 shows, in diagrammatic form, a section of such a central station, so as to exhibit one unit of plant, the other units being arranged side by side. The pump discharges through the valve-box situated in the suction tank. This tank also serves as an isolating tank. The discharge pipe conveys the water into a large air vessel placed outside the building. This air vessel is connected with other similar air vessels by a common air pipe at the top, which maintains the air pressure the same in all the vessels, and a common water main at the bottom. The water is fed to the turbine by a pipe, and the turbine discharges into a longitudinal canal, which has a connection to each of the suction tanks. The turbine is direct coupled to the electric generator, and the current may be taken to the switchboard, which is conveniently placed overlooking the machinery. The necessary isolating valves are shown, and it will be noticed that the working parts of the pump, as also the turbine and generator, are so situated as to be supervised from a common platform. The gas main runs longitudinally outside the building.

The advantages of such an arrangement are fairly obvious, and arise chiefly from the simplicity of the working parts, the absence of noise and shock, and from the exceedingly low cost of upkeep. In gas engine stations using cheap producer gas or blast furnace gas the cost of lubricants and stores frequently exceeds the cost of the fuel, but in the present instance there is practically no lubrication required, and the author has worked one of his pumps for a week at a time with absolutely no lubrication whatever. Of course, one has to face the loss due to the conversion of the water power into mechanical energy, but the efficiency of a well-designed turbine is not less than 80 per cent. at full load, and there is no need to work any of the pumps at less than full load. The ease with which the pumps can be started and stopped from the switchboard gives the electrician complete control of his station and the ability to start up one or more pumps at a moment's notice. In fact, even this arrangement can be simplified, because the governing of the pumps can be so arranged that a steady pressure is kept on the air vessels irrespective of the demands, and a slight rise in this pressure may automatically cut out one pump and its attached dynamo after another, and re-start them again as the pressure falls. Based on the efficiencies so far obtained, a Board of Trade unit can be generated for 2 lb. of anthracite coal, and with the large units of plants required in central stations this figure should be much reduced. Even if the fuel economy should not prove to be higher in such a station, yet its other advantages may more than compensate for this defect. One other aspect of this question might be mentioned, and that is, if the contour of the district is such as to permit the construction of a high-level reservoir of considerable capacity in proximity to the pump-house, water can be pumped into this reservoir and be drawn upon as required. This would enable the pumps to work steadily day and night on a 100 per cent. load factor, and would reduce the quantity of plant, in so far as the gas producers and pumps are concerned, to the minimum possible.

If the internal combustion pump proves in the future to be a successful competitor of the gas engine for power purposes, then it is probable that one of the most useful fields for its employment will be found in the propulsion of ships. Quite apart from the possibility of driving a turbine attached to a screw propeller, there is the much more efficient jet propeller, which is the most efficient of all propellers for ships if properly constructed and operated. What has been lacking so far has been a type of pump capable of delivering very large quantities of water at comparatively low heads, and it is just these conditions which suit the author's pumps in their simplest form. It would carry us too far to follow up this line, and one must be content with merely throwing out the suggestion, especially as the short time remaining must be devoted to the description of some details of the pump.

Pump details.—In all the diagrams except the first, the mechanism which controls the valves has been omitted, but in Figs. 20 and 21 some details are presented. These figures represent a recent design of valve chamber suitable for either a two-cycle or four-cycle pump, the curious fact being that exactly the same

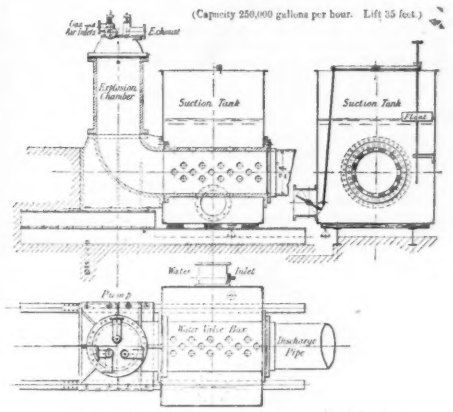


FIG. 22. *Pump as Designed for the Brussels Exhibition (1910).*

mechanism serves for both cycles. During the experiments precisely the same pump and gear was, by altering the conditions, made to operate on either cycle at will. In the figure three valves are shown—the admission valve, the scavenging valve, and the exhaust valve. The last-mentioned valve is situated at a lower level than the others, and above this valve is situated the cushion chamber, which also forms part of the explosion chamber, in which the charge is compressed before ignition. The valve stems each carry top and bottom circular nuts a, b, c, d. The latter serve to limit the opening of the valve by coming in contact with the rubber buffers, and the top nuts serve to lock the valves in their closed position when the bolt e slides between the under side of the nut and the top of the brackets. The remaining gear will be sufficiently understood if its operation is described. Starting with all the valves shut, ignition occurs followed by expansion. The locking bolts are at this time in such a position that the admission valve is locked and the exhaust and scavenging valves are free to open. The expansion is rapid, and as the point of atmospheric pressure is passed, suction causes the exhaust valve and the scavenging valves to open simultaneously. In the exhaust pipe there is a light non-return valve placed so that it is normally closed. This prevents the suction from drawing back exhaust products and causes a rush of air past the scavenging valve into the chamber, so that the top portion of the chamber is well swept out. The suction is soon over, and, the water column beginning to return, the scavenging valve shuts under the action of its spring, but the exhaust valve remains open while the products are discharged. When the water reaches the exhaust valve it shuts it by impact, and the cushion and cushion expansion stroke, followed by the suction stroke, results. It will, however, be seen that when the exhaust valve shuts, the enlarged portion of its lower nut, bearing against the curved lever f, which is hinged at g, forces this lever to the left. As another curved lever h is hinged to the first lever by means of the link j this other lever has also to partake of the motion and move to the left, thus setting it in position to be acted upon by the lower nut on the inlet valve. Link j carries a pin k, which engages against a lever l, hinged at m in such a manner that when link j moves to the left the top of lever l moves to the right. Two springs are shown attached to lever l, that on the left being stretched, and that on the right being closed, and as these two springs act upon the bolt e in the position shown, the effect is to urge the bolt to the right. This bolt cannot, however, move until the top nut c has risen to its full height, which occurs when the exhaust valve shuts. The movement of the bolt then takes place and locks the exhaust shut, at the same time releasing the admission valve. Consequently, when the cushion expansion stroke is followed by the charging stroke the suction opens the admission valve and a fresh charge is drawn in. The opening and shutting of the admission valve reverses the action of the gear, locks the admission, and unlocks the exhaust ready for the next cycle. It should be explained that the bolt which controls the scavenging valve is pivoted at n, Fig. 21, and has one end fastened to the bolt e, so that this end partakes of its motion. Whether the rise and fall of liquid which drives out the products

*The Institution of Mechanical Engineers.

and takes in the fresh charge is due to an oscillation of liquid between the supply tank and the chamber, as in the two-cycle pump, or due to a reversal of flow in the discharge pipe, as in the four-cycle pump, makes no difference to this gear.

The only other working part is the water supply valve, which, of course, is purely automatic in its action. A single valve, as illustrated in the diagrams, would need to be too large and heavy to be practicable except for small sizes of pumps. Consequently the single valve is replaced by a number of valves. An arrangement which the author has found very effective is shown in Fig. 22, where a cylindrical valve box is pierced by a number of holes each fitted with a simple gun-metal valve held on its seat by a light spring. In Fig. 22 the valve-box is shown as placed immediately after the pump, and so virtually forms part of the discharge pipe. One very interesting fact should be noted in connection with the water valves. Each valve is normally held closed by a spring of such strength that it readily allows the valve to open when suction occurs. Now suppose that one or more of the water valves is fitted with an attachment which alters the compression of the spring so that the spring no longer brings the valve to its seat under normal conditions. The valve or valves thus fitted do not shut with the other valves, but water flowing through them causes them to shut under the action of the velocity. The result of such an arrangement is important, because it allows the pump to keep on working even if no explosion occurs. Thus, if a charge contains too much gas or air and fails to explode, it will expand again after compression and be exhausted, and a fresh charge drawn in, the pump continuing to work at the expense of a small quantity of energy representing the amount of water which falls from the high to the low level and escapes past the water valve mentioned. It is not usually desired that this should be a normal condition of affairs, but it is useful at any moment to be able, by moving a lever, to keep the pump running without explosions. By purposely exaggerating this action, and suitably altering the inlet and exhaust valve mechanism, the pump may be converted into an air compressor for compressing air by the energy of falling water.

In concluding this paper, the author wishes to express his indebtedness to those of his assistants who have taken an active share in the development of the pumps, and especially to Mr. W. J. Rusdell, who has taken the keenest interest in the experimental work, and who originated the suggestion that the cushion stroke, instead of being produced by an oscillation of the supply water, should be caused by a reverse flow in the discharge pipe, thus making the two-cycle into a four-cycle pump. Mr. Allen Nicholls, B.Sc., has had charge of the electrical ignition devices, and has succeeded in producing a sparking-plug which is absolutely reliable when washed by water at each stroke.

NORTHAMPTON POLYTECHNIC INSTITUTE.—The annual prize distribution and students' conversazione will be opened this evening at 6 30, and at 7.30 Sir John Wolfe Barry, K.C.B., will distribute the prizes and certificates. The conversazione for members and students will be continued on Saturday, the 11th inst., when the building will be thrown open to the whole of the members and students and their friends.

INSTITUTION OF ELECTRICAL ENGINEERS.—The Glasgow section of the Institution of Electrical Engineers held its eighth annual dinner in the Grosvenor Restaurant on December 1st, Mr. E. George Tidd presiding. Amongst those present were Dr. Gisbert Kapp, President of the Institution of Electrical Engineers, London, Dr. Robert Caird, Greenock, and Professor Archibald Barr, Glasgow University. In proposing "The Institution of Electrical Engineers" Dr. Barr referred to the progress it had made. It was only in 1871 that the Institution was formed and in 1888 that it assumed its present form and name. It had now over 6000 members. Dr. Kapp, in reply, said that the history of electrical engineering was largely made up of a race between this country and Germany and America. Sometimes one country was a little ahead and sometimes another, but in the long run this country was not found to be behind the others. He compared this competition to a race in which the horses were not always in the same position, and in which there was no winning post. There was, he said, no finality in electrical engineering, and that made the rivalry between the nations all the more interesting.

NEW HIGH-PRESSURE FIRE INSTALLATION.—A test was recently carried out at the Royal Palace Hotel and Empress Rooms, Kensington, with a new fire protective installation which has lately been fitted up by Merryweather and Sons in connection with the Hydraulic Power Company's main. The main carries water at a pressure of 750 lb. to the square inch, and a special hydraulic hydrant is provided by means of which the pressure at the discharging nozzle is reduced to a pressure such as can readily be withstood by ordinary canvas hose. Ten of these hydrants are provided on the various floors of the building, each fitted with 120ft. of canvas hose and nozzle, enabling a fire to be promptly attacked from any point where it may break out. A jet was brought into play on the roof, which is over 100ft. from the ground, and it was found that the pressure was ample for fire-extinguishing purposes. At such a height as this the pressure from the ordinary water supply mains would be inadequate. A special feature of the hydrants is that they are each fitted with a relief valve, so that, in the event of the hose becoming kinked or twisted, this valve automatically operates and prevents a burst hose resulting.

PRESENTATION OF THE DENNY GOLD MEDAL.—At the Institute of Marine Engineers on Monday evening, November 15th, the Denny Gold Medal was presented to Mr. Wm. P. Durtnall (Member), for his paper on "The Generation and Electrical Transmission of Power for Main Marine Propulsion and Speed Regulations," read in July, 1908. In making the presentation, Mr. J. T. Milton, Chairman of Council, said the paper Mr. Durtnall had given was a very valuable one, and several useful discussions had taken place upon it. It was a subject which was giving a great deal of thought to engineers, and the Council of the Institute considered the paper to be the best submitted during the session and well worthy of the award. Mr. Durtnall, in acknowledging the presentation, said he valued the Medal very highly, as he was a member of the electrical profession, which profession would, in his opinion, become more closely allied to marine engineering in the near future. He had pleasure in informing the members that the subject was being taken up in a practical way. A cargo boat would be fitted with this system of propulsion in about seven months' time, and he would be pleased to present the results of the trials of that vessel to the Institute as soon as they could be ascertained.

JAPAN-BRITISH EXHIBITION.—A Japan-British Exhibition is to be held next year at the White City at Shepherd's Bush, under the auspices of the Japanese Government. Its principal object is to give visitors complete information as to Japan's most important products, and her advance in various industries. In the Machinery Hall at the Exhibition the exhibits are to be purely British, and we understand that large spaces have already been allotted to Sir W. G. Armstrong, Whitworth and Co., and to Vickers Sons and Maxim, Limited, amongst other large firms. All the other portions of the Exhibition will be devoted to comparative exhibits of British and Japanese manufactures. As Count Mutsu, Councillor of the Japanese Legation in London, has publicly declared, an endeavour will be made to draw attention to some Japanese products which are, as yet, unfamiliar in this country, and, if possible, to give an impetus to Japanese exports to Great Britain, which are at present only a quarter of our exports to Japan, and only one-fifth of that country's exports to the United States. It is not intended to compete with our home industries, seeing that the principal items of export to Great Britain, such as various sorts of silk, rice, copper goods, &c., do not interfere with our own productions.

DOCKYARD NOTES.

THE latest report of the German Thuringen class is as follows:—There are three ships of this class, Thuringen, Heligoland, and Ostfriesland; displacement, 22,000 tons; length, 489ft.; beam, 98ft.; draught, 27½ft.; speed, 20 knots; Schulz boilers, piston turbine engines; three screws; armament—twelve 12in. of 50 calibres, fourteen 6in., twenty 24-pounders, six 19.5in. torpedo tubes; armoured belt, 12in. These details are just as likely to be correct as any other details that have been published. They are also just as likely to be incorrect. Extremely little is known about these ships. In order to maintain secrecy all sorts of fancy wooden erections are built upon them; and it is impossible to say whether they will carry all their guns on the centre line, as originally designed, or whether they will be simply enlarged Nassaus. The probabilities, however, are in the latter direction, the main feature of all modern German naval designs being an extreme conservatism and absence of any originality.

THE German destroyer G 171, fitted with Parsons turbines, built by Krupp, has made a speed of 39 knots. This is the record speed yet obtained by any German destroyer. The class to which G 171 belongs are all of 616 tons displacement.

IT is officially announced that Argentina has ordered four destroyers in England, four in France, and four in Germany.

THE old Italian battleships Duilio, Dandolo, Ruggiero di Lauria, and Andrea Doria, are, it is announced, all going to be turned into coal depôts. Four old cruisers are going to share the same fate, and it is calculated that by these arrangements there will be a squadron of colliers capable of carrying 50,000 tons of coal. So far as the old battleships are concerned, the saddest thing is to think that they were all Dreadnoughts in their era. Each of them was the "last word in naval construction." And this is what they have come to!

THE four new Italian Dreadnoughts under construction or contemplated are provisionally named Dante Alighieri, Leonardo da Vinci, Michael Angelo, and Cavour. These four should be completed in 1912, though it is extremely improbable that they will be. Four further Dreadnoughts, sisters to the above, are also contemplated for completion in 1914.

IN addition, Italy is reported to have ordered from the firms of Ansaldo, Odero and Orlando, three cruisers destined to replace three of the Ligura class. It is rumoured that these ships will be sisters to the Pisa, and that they will have turbine machinery and Belleville boilers.

THE German active naval *personnel* is being raised from 54,000 to 57,500 men.

A CHILIAN Naval Commission under Rear-Admiral Perez is at present touring French dockyards in connection with the expansion of the Chilian navy. It is expected that it will subsequently visit this country and tour our yards; also the German yards. It is unlikely, however, that any orders will be secured here, or, for that matter, in France either, owing to the German practice recently instituted of the Government arranging for a substantial rebate, with an eye to the fact that, in the event of war occurring as the vessels near completion, they may be purchased and used. The naval aspirations of South American Republics have put an entirely new aspect on naval construction.

IT will be remembered that some time ago the Russians re-engined and re-boilered their gunboats of the Teretz class, six in number. It appears that all these gunboats have also been re-armed as follows:—Two 6in. 45-calibre, one 4.7in. 45-calibre, two 12-pounders, four 3-pounders, two 1-pounders, and one machine gun.

THE French destroyer Voltigeur made her official full-power trials last week and obtained a mean speed of 31.3 knots, or 3.3 knots above contract speed.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Improvement in Manufactured Iron.

A REASSURING effect has been exerted by the new return of the accountants to the Midland Iron and Steel Wages Board. The figures for September and October show that although the return does not indicate sufficient betterment to occasion any alteration in wages, yet that a definite improvement has taken place both in selling prices and in output compared with July and August. The new bi-monthly average selling price is £6 3s. 9.52d., or an increase upon the last return of 1s., whilst the sales made by the 17 selected firms totalled 37,322 tons, which was an advance of 5830 tons. The increased production affects all descriptions, embracing bars, angles, and tees, plates and sheets, and hoops, strip, and miscellaneous. The sales effected in the two months of September and October are as follows:—Bars, 23,995 tons; angles and tees, 775 tons; plates and sheets, 1596 tons; hoops, strip, and miscellaneous, 10,955 tons. The average price of bars, compared with the previous bi-monthly return—for July and August—was 1s. better, plates and sheets improved by 2s. 3d., and hoops were practically without alteration. An important characteristic of the new return is that angles and tees increased by as much as 4s. 2d. per ton in price. Evidently the makers have been getting some good terms lately from constructional engineers. The increased output is attributable to the trade improvement which was experienced at the beginning of September.

Good Shipments of Corrugated Sheets.

Almost at the same time as the foregoing favourable return, there come very satisfactory Board of Trade figures as to the exports of galvanised sheets. During the eleven months of this year the quantity exported was 441,455 tons, or an increase on the corresponding period of last year of 86,742 tons, whilst the value reached the excellent total of £5,850,869, which was an augmentation of £911,432. Most of the leading markets have been buying better than a year ago, the three chief increases being India, from 82,631 tons to 90,038 tons; the Argentine Republic, from 61,801 tons to 85,029 tons; and Australia, from 56,576 tons to 74,937 tons. With reference to the trade of the single month of November, the shipments amounted to 47,569 tons, or an increase of 11,119 tons, whilst the value was £569,079, or an improvement of £69,944. Heavy advances in quantity were shown by India (which nearly doubled its purchases), Australia, Canada, Chili, and some other markets. Altogether the new figures, both for the long and the short period, are very satisfactory. The general quotation this week continues £11 to £11 5s. for 24-wire gauge f.o.b. Liverpool.

Other Descriptions.

Gas strip is quoted £6 5s., and slit rail rods are £7. Marked bars remain at £8, with a fairly good demand, whilst unmarked sorts are £5 17s. 6d. to £6, with inquiry only moderate. Plain black sheets are rather improved at £7 2s. 6d. to £7 5s. for doubles.

Pig Iron Rallying.

There is a disposition to rally on the part of pig iron, the aim of makers being apparently to tide over the interval between now and the opening of the New Year with as few concessions as possible, and with quotations at a favourable level for taking advantage of the improved demand which it is hoped will then be experienced. Meanwhile, quotations, although less shaded than recently, remain, for prompt business, practically the same as a week ago, cinder forge pig being 45s. to 46s., part-mines 48s. to 49s., best all-mine forge 85s., and foundry 90s. Northamptons are 47s. to 48s., and Derbyshires 48s. to 49s. Quotations for forward delivery are higher than these. Coke keeps up in price, and is expected to be dearer still before long.

NOTES FROM LANCASHIRE.

(From our own Correspondent.)

MANCHESTER, Thursday.

Bad Outlook in Pig Iron.

ALTHOUGH reports from other centres show signs of a revival in pig iron, it would seem that the demand is chiefly for continental and American account. Shipments from both East and West coast ports continue heavy, but in Manchester the demand is very slow and of a hand-to-mouth character. Foundries are very slack throughout the district, and with a continuance of the slow movement in the engineering trades generally, there is keen competition amongst merchants for the few orders being given out. This remark, however, only applies to delivery to the end of the year. For the opening months of 1910, a premium of 2s. 6d. per ton is being asked in most instances on account of the higher prices of fuel, which are expected to rule. We have no change, practically, to note in pig iron for the week. Forge iron is, if anything, in buyers' favour.

Finished Iron and Steel.

Great quietude prevails in most departments. It is noteworthy that foreign competition in billets on spot is practically nil, and prices are nominal for this class of steel.

Copper, Lead, and Tin.

Copper: Although raw copper is higher, there has been no further advance in manufactured stuff. In any case merchants say that an advance in this district would be useless, as inquiry is of a very restricted character. Lead: Sheets remain quietly steady. Tin: English ingots firmer, to 20s. per ton higher.

Quotations.

Lincolnshire No. 3 foundry, 55s.; Staffordshire, 53s.; Derbyshire, 55s.; Middlesbrough, open brands, 59s. 7d. to 59s. 10d. Scotch: Gartsherrie, 61s.; Glengarnock, 60s. to 60s. 6d.; Eglinton, 59s., delivered Manchester. West Coast hematite, 61s. to 61s. 6d.; East Coast ditto, 60s., both f.o.t. Delivered Preston: Gartsherrie, 60s.; Glengarnock, 59s. to 59s. 6d.; Eglinton, 58s. Delivered Heysham: Gartsherrie, 59s.; Glengarnock, 58s. to 58s. 6d.; Eglinton, 57s. Finished iron: Bars, £6 10s.; hoops, £7 12s. 6d.; sheets, £7 12s. 6d. to £7 17s. 6d. Steel: Bars, £6 2s. 6d. to £6 5s.; Lancashire hoops, £7 5s.; Staffordshire ditto, £6 17s. 6d. to £7; sheets, £7 17s. 6d. to £8; boiler-plates, £7 5s. to £7 7s. 6d.; plates for tank, girder, and bridge work, £6 5s. to £6 7s. 6d.; English billets, £4 12s. 6d. to £4 15s.; foreign ditto nominal; cold drawn steel, £9 10s. to £9 15s. Copper: Sheets, £72; tough ingot, £62; best selected, £62 per ton. Copper tubes, 8⅞d.; brass tubes, 7¼d.; condenser, 8¼d.; rolled brass, 6¾d.; brass wire, 6¾d.; brass turning rods, 6⅜d.; yellow metal, 6⅛d. to 6⅜d. per lb. Sheet lead, £17 per ton. English tin ingots, £142 per ton.

The Lancashire Coal Trade.

The only sign of activity in the coal trade is in household fuel. This has been stimulated by the cold snap, but although some of the Lancashire collieries are behind with their deliveries in this department, it is now pretty certain that there will be no advance. Outside competition from Yorkshire and Derbyshire is very keen, and this would also tend to prevent it. In the shipping department there is more life at Partington, and some large boats have left the canal coal-laden recently. Furnace coal and slack rather dull.

BARROW-IN-FURNESS, Thursday.

Hematites.

The demand for hematite pig iron is only moderate, and the business done during the week has been quiet and of small aggregate bulk, but there is nothing on the market which shows any real depression. True it is that more iron is being produced than is being sold and consumed, and equally true that stocks of metal are increasing in makers' yards, but this is not resulting either in any reduction of output or in any disposition to take a gloomy view of the situation. The crude iron trade depends very largely on the steel trade, as this represents the great feature of consumption, and at the moment steel makers are not taking such full deliveries of iron as usual. The consequence is that more metal is being thrown into the open market. Prices are a shade easier on the market, and mixed Bessemer numbers are quoted at 62s. net f.o.b., while warrant iron sellers are at 60s. 6d. net cash, and buyers 3d. less. Three months' deliveries are quoted at 62s. sellers, and 61s. 9d. buyers. Special hematites, for which there is a good steady demand, are at 64s. to 65s. Ferro manganese and spiegeleisen are in request, and business in charcoal iron and scrap iron is satisfactory. Iron ore quieter at 11s. 6d., 14s. and 18s. net at mines for ordinary medium and best sorts. Very little foreign ore is being imported.

Steel.

There is a quiet market for Bessemer classes of steel, and practically no market for mild steel. The plate mills at Barrow, which have been idle for twenty months, are yet at a standstill, and there is very little doing in merchant sorts.

Shipbuilding and Engineering.

It is generally understood that the order for the battleship cruiser required by the Admiralty will be placed with Vickers, Sons and Maxim. This firm is already very busy in all departments, and expects to be well employed for some time to come.

Shipping and Coal.

Business in shipping circles is much brisker than it has been. The exports of iron and steel from West Coast ports last week amounted to 18,881 tons—iron 7882 tons and steel 10,999

tons—as against 10,235 tons for the corresponding period of last year, an increase of 8646 tons. For the year to date the shipments aggregate at 585,038 tons, against 468,512 tons in the corresponding period of last year, an increase of 116,526 tons. Coal and coke are firmer, and prices show an improvement.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Coal Trade.

BUSINESS in the various departments is well maintained, and the alteration, if anything, is towards a better tone. The approach of the holiday season is causing considerably more to be done in domestic fuel, though steam coal is at present in what is usually the quiet season, pending the settlement of contracts for next year. Signs of improvement, however, are perceptible in the hard coal market, and the export trade, having regard to the time of the year, is very well maintained. Pits are working four to five days a week. Some complaint is heard of shortage of wagons, and consequent loss of time.

Railway Coal Contracts, &c.

The railway companies' contracts, for which inquiries have been received by the various coalowners, are yet in abeyance as regards the principal contracts. The coalowners have given their quotations at 9s. 3d. per ton, a price which represents an advance of 9d. per ton on last year's contracts. This rate has been explicitly declined by the railway companies. No further negotiations have yet been set on foot, as there are still arrears to deliver. In view of the hopeful feeling entertained that next year will bring better prices and more limited output, owing to the operation of the Eight Hours' Act, coalowners at present are in a position to stand out as to the future. It is reported that the Midland Company has been able to buy in West Yorkshire supplies of coal under contract from small collieries at an advance of 6d. per ton on last year's prices; but this is not regarded as a matter of great importance in South Yorkshire, from which the bulk of the supplies is drawn. Contracts for shipment are made in the early spring, and the advance is looked for then as well. Inquiries are coming forward as usual in the interval, but it is not likely that any arrangements will be made until the New Year. Since our recent reference to the Cunard and Elder Dempster Companies' purchases from a local colliery, we have not heard of other arrangements of any size in further contracts for coal for bunker purposes.

House Coal More Active.

As usual at this time of the year before Christmas, and partly because of colder weather, there is now rather a brisk demand for domestic fuel both on distant and local account. A good business is doing with the London and Southern markets, as well as for the Eastern Counties districts. The advance of 1s. per ton, which we mentioned as unofficially asked for, is being easily obtained. Current rates are as follows:—Best Barnsley, 12s. 6d. to 14s. per ton; secondary descriptions, 10s. 6d. to 11s. 6d. per ton. The West Yorkshire house coal trade keeps active.

Small Coal and Coke.

A good trade is still being done in the best qualities of small coals which are largely used in the Lancashire and Yorkshire mills. The quotation has not changed for a considerable time—4s. 6d. to 5s. 6d. per ton. Lower grades of slack are not quite so freely called for. The prices of furnace coke are well maintained, but just at present there is a slight weakening, owing to the local iron market not being of so hopeful a character as could be wished. There is, however, no reason for this, as all the iron made in the district is being absorbed. Quotations are maintained, viz.:—Best washed, 12s. 6d. to 13s. per ton; unwashed, 11s. 6d. to 12s. per ton.

Iron—Situation Unchanged.

A quiet tone continues to mark the pig iron market, and there is no likelihood of any change whatever this year. Ironmasters do not exhibit eagerness to press sales, as they are well sold forward, and they are convinced that more money will be obtained in the New Year. Deliveries, so far as this month has gone, have been slightly better than in November. The Lincolnshire Ironmasters' Association hold their usual fortnightly meeting on the 10th inst., but it is not anticipated here that any change in prices will be made. Quotations, all net, and delivered in Sheffield and Rotherham, are as follows:—West Coast hematites, 68s. to 70s. per ton; East Coast, 65s. to 67s. per ton. Lincolnshire: No. 3 foundry, 52s. 6d. per ton; No. 4 foundry, 51s. 6d. per ton; No. 4 forge, 51s. 6d. per ton; No. 5 forge, mottled, and white, 51s. 6d. per ton; basic, 52s. 6d. per ton. Derbyshire: No. 3 foundry, 52s. per ton; No. 4 forge, 50s. 6d. per ton.

Bars, Hoops, and Sheets.

Still no improvement to report in finished iron and allied trades. Bars, £6 10s. per ton; hoops, £7 10s. per ton; sheets, £8 10s. per ton.

The East End Works.

The heavy trades, as regards armour plates, projectiles, and war material, are finding a fair amount of work at the present time, but the earlier processes in the production of armour plates are for the most part now completed; the finishing stages are still being proceeded with, and will continue for a few weeks into the New Year. The new orders are being anxiously looked for. Several orders for projectiles, received a few weeks back, are also rapidly being completed, and, excepting in special lines, the large forging presses are becoming short of work. Railway material still continues very flat in demand, and no fresh orders of magnitude have come to hand for months back, either for home or foreign requirements. The hope was entertained that South America might come more largely into the market, and some small orders have been received for tires, axles, springs, &c. The Colonies are at present providing a fair amount of work. The sum total of all that is being received, however, is not sufficient to afford half employment for the capacity of the various establishments engaged in the manufacture of railway material. The home companies are ordering very sparingly. Marine material still in depressed condition.

Cutlery Exports—Increase in November.

The colonial and foreign trade in cutlery considerably advanced during November, the exports showing a value of £64,834, against £48,878 and £66,308 for the corresponding months of 1908 and 1907. The value for the eleven months of the year is £491,435, against £563,460 in 1908, and £710,859 in 1907. The principal market was Australia, with a value of £10,235, against £8582 in November of last year. Canada comes next with a value of £8989, against £6426. A feature of the month's trading is the improvement in South Africa, which had advanced to £7847 from £4007 in November of last year. The United States rank fourth with £7613, against £5870.

Government Requirements in Cutlery.

Tenders are out for the requirements of the Government departments in cutlery during 1910. The Admiralty ask for 45,000 table knives, 19,000 dessert knives, 1300 steels, and about 10,000 can openers. The War-office require 10,500 each of carving knives, forks, and butchers' steels.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Iron.

THIS week a better state of business is to be reported in the Cleveland pig iron trade than was ruling last week, and, indeed, for two or three weeks previously, when the market was somewhat depressed, and prices moved downwards. A recovery is now apparent, the tone is becoming rather buoyant again, confidence seems to be returning, and quotations are being advanced, though it cannot as yet be said that the amount of buying is extensive, and it is held that it will not be until the general election is over. In any case, this is not the season when one can expect much upward movement, for the winter is the quietest time of the year, and people generally put off purchasing for spring delivery until February. Still, the outlook is promising for 1910, and the market is being strengthened by the reports concerning the Stock Exchanges and other metal markets, in addition to which there is the decided improvement in several branches of the finished iron and steel trades, which is not brought about by speculation, but by a genuine revival of trade. In view of these favourable features the unsatisfactory statistics—the rapidly increasing stock of pig iron in Connal's store and the very poor exports—fail to have a detrimental influence on the market. It used to be that when stocks went up prices dropped, but that no longer holds. Traders still expect that American demands will next year clear off most of the stock of Cleveland pig iron that is held, and probably this is one reason why the makers have not followed their usual policy of not accumulating stocks, but reducing their production when the demand for pig iron becomes small. So far the Americans have bought comparatively little Cleveland iron, but the revival in the United States appears to be more in steel than in ironfounding. It is for the latter that most of the Cleveland iron is sent. Hitherto the American furnaces have been able to supply all that the native ironfounders have required, but Cleveland iron can now be delivered at as low a figure as 70s. per ton at New York, Philadelphia, or Baltimore, and that should tempt the consumers in the States bordering on the Atlantic. The Rhodesia has sailed from the Tees this week with pig iron for the States, and the Dundonian has been chartered to carry 5000 tons from the Tees to Philadelphia at 5s. 6d. per ton, but the sale is said to have been made some considerable time ago. The quotations for Cleveland pig iron have moved upwards this week, makers asking 50s. 6d. per ton for prompt f.o.b. deliveries for No. 3 G.M.B., or 6d. more than a week ago, while No. 1 is at 52s. 9d.; No. 4 foundry at 49s.; No. 4 forge at 48s. 9d., and mottled and white at 48s. 3d.; but for delivery over the first quarter of 1910 fully 1s. per ton more is asked in each case. Another 3d. per ton was added to the prices on Wednesday, the market being considerably strengthened by the figures of the November Board of Trade returns, which furnish evidence of a general revival of trade.

Hematite Pig Iron.

Most traders speak well of the position and prospects of the East Coast hematite pig iron business. They are certainly encouraging, and it is not likely that prices will be lower. Makers maintain their quotation for mixed numbers for early delivery at 60s. per ton, which is the highest price of the year, and is 5s. 6d. above the minimum. Hematite pig iron producers are not troubled by the accumulation of stocks. They have little in their own hands, and there is none in Connal's public store, nor has there been any there since the spring of 1906. Not for fourteen years has there been any considerable quantity. Thus the hematite iron market, as far as regards quotations, is much steadier than the market for Cleveland iron. Since the upward movement set in, prices of hematite iron have not had a single set-back, and they have risen more than Cleveland iron. Makers are asking 62s. 6d. per ton for mixed numbers delivered during the next quarter, and 65s. up to the end of the year. Rubio ore is still nominal at 17s. 6d. per ton c.i.f. Middlesbrough, early delivery. Coke is very firm, and it is expected that higher prices will have to be paid for next year; indeed, sellers are asking more. The production even now is hardly equal to the requirements, and the latter are increasing. There are now 83 blast furnaces in operation in the North-East of England, of which 39 are producing hematite and other special kinds of pig iron, and 44 ordinary Cleveland iron.

Stock and Shipments of Pig Iron.

It must be acknowledged that the present statistical position of the pig iron trade in this district is not satisfactory. The stock continues to increase rapidly, and is now 233,000 tons more than it was at the commencement of the year. It is strange that the makers have not reduced their output, but latterly the idea has been that America would need considerable quantities of Cleveland iron, and this would deplete the stock in the public stores as quickly as it did two years ago. On Wednesday the stock in Connal's was 370,531 tons, the increase over the first week of the month being thus 7313 tons. The stock consisted of 337,273 tons of No. 3, 30,523 tons of other iron deliverable as standard, and 2735 tons not so deliverable. The pig iron exports from the Cleveland district this month are the worst this year, and are not likely to improve, for wintry weather is greatly curtailing deliveries to the Continent. The quantity shipped up to the 8th was 14,981 tons, compared with 20,004 tons last month, 18,946 tons in December, 1908, and 28,184 tons in December, 1907, all to the 8th.

Manufactured Iron and Steel.

The situation in the finished iron and steel industries has so far improved that advances in prices have been generally expected. Evidently the competition is still too keen to permit producers to raise their quotations. There are indications of good trade next year, and manufacturers do not want to put anything in the way of realising it by advancing their rates before the demand fully justifies it. The best business is done at present in shipbuilding materials, and there are also good orders for sheets (black and galvanised), wire, hoops, and rails, but the bar trade is very slack. Rail manufacturers are well off for orders, but nevertheless would like to have a better supply of contracts for the second quarter of the year. The best deliveries of rails this year have been to South America, and of that trade the United States manufacturers are determined to have a share. They have commissioned agents to visit South America, especially the Argentine, and get the orders regardless of price, but they must cut out other countries. German rail makers are likewise endeavouring to secure contracts from South America, where railways are being constructed at a rapid rate. From the Tees alone this year over 120,000 tons of steel, mostly rails, has been forwarded to Argentina, which is more than has been sent to any other country, not even excepting India.

Shipbuilders.

Business is steadily improving in the shipbuilding industry, and the outlook for the winter is very much better than the most sanguine had expected. Trade is evidently better for the shipowners, as the number of vessels laid up has not increased, and it was believed that with the closing of the Baltic our rivers would be crowded with idle shipping. Orders for new vessels are being booked at a very satisfactory rate. Messrs. William Gray and Co., West Hartlepool, have this week booked an order for a large cargo steamer, and Messrs. W. Pickersgill and Sons, Sunderland, one of 5800 tons for a Cardiff firm. The Dominion Coal and Iron Company, which recently ordered three colliers of between 7000 and 8000 tons each from Sunderland shipbuilders, is reported to have ordered two more from Tyneside builders. The British India Steam Navigation Company is in the market for a new passenger cargo steamer. Smith's Dock Company has now completed the removal of its shipbuilding business from North Shields to the Tees, where it will have twelve building berths, some of them for trawlers. It has orders for six steamers already on the books. The new dry docks which it opened this year on the Tees are regularly occupied by steamers needing repairs. At North Shields they will devote themselves to the repairing of vessels.

Coal and Coke.

Quite a change has lately come over the coal trade. The steam coal business is no longer depressed, but there is plenty of inquiry, and good orders are reported to have been placed on Australian and South American account, both for steam and gas coals. The improvement is leading to advances of prices, best steam having gone up to 11s. 6d. per ton, seconds to 9s. 6d., and smalls from 5s. 6d. to 7s., according to quality. Best Durham gas coals are up to 11s. 3d. per ton f.o.b., and bunkers have risen 6d. per ton this week, 9s. 9d. to 10s. 3d. per ton being quoted for delivery at Tyne Dock. The tendency in coke prices is upwards, and for Durham furnace coke 17s. 6d. per ton delivered only at Middlesbrough has to be paid. Considerably more is asked for forward, but consumers are not prepared to pay higher figures, for even now coke is relatively dearer than pig iron.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

The General Trade Position.

THE position of trade generally has been gradually improving, and the state of employment is more satisfactory. The local poor authorities report a large decrease in the applications for relief compared with this time last year. A central labour exchange has been established in Glasgow by the Board of Trade, which has taken over as its nucleus the institution of that name started several years ago by the Town Council. Of course, it is to be greatly enlarged, and is to be the clearing-house exchange for all the other labour exchanges to be established in Scotland. The exchange is expected to be an advantage both to employers and workmen.

The Pig Iron Market.

The depression that characterised the warrant market last week has been succeeded by a considerable improvement this week in the amount of business done and also in prices. The lower rates touched last week afforded an opportunity to speculators to come in for a favourable turn, of which advantage has been taken, and a fair proportion of the business has been for future delivery. Cleveland warrants have sold since last report from 49s. 10½d. to 50s. 8d. cash, 50s. 2½d. to 51s. one month, and 50s. 11d. to 51s. 8d. three months. Transactions are also recorded at 50s. 2d. for delivery in nine days, 50s. 9½d. ten days, 50s. 7d. twenty-one and twenty-six days, 50s. 10d. and 50s. 11d. twenty-four days, 50s. 9d. for 21st January, and 51s. for 13th January. These transactions cover a considerable revival of speculative interest in warrants. There has been some inquiry for hematite, but scarcely any actual business reported.

Scotch Makers' Iron.

The demand for pig iron on the part of home consumers has been quiet, and there is not expected to be much improvement until the turn of the year. The inquiry for abroad has been moderate, and distributed over many countries, but the supplies required are generally individually small. Some of the makers' brands were reduced 6d. and 1s. per ton as a result of the depression in warrants last week, but the quotations this week are better maintained. Free at-ship in Glasgow harbour, Monkland, No. 1, is quoted 57s.; No. 3, 55s.; Carnbroe, No. 1, 59s. 6d.; No. 3, 56s. 6d.; Clyde, No. 1, 62s.; No. 3, 57s.; Gartsherrie, Calder, and Langloan, Nos. 1, 62s. 6d.; Nos. 3, 57s. 6d.; Summerlee, No. 1, 63s. 6d.; No. 3, 58s. 6d.; Coltness, No. 1, 88s.; No. 3, 58s. 6d.; Eglinton, at Ardrossan or Troon, No. 1, 58s.; No. 3, 56s.; Glengarnock, at Ardrossan, No. 1, 64s.; No. 3, 59s.; Dalmellington, at Ayr, No. 1, 61s.; No. 3, 56s.; Shotts, at Leith, No. 1, 62s. 6d.; No. 3, 57s. 6d.; Carron, at Grangemouth, No. 1, 64s.; No. 3, 58s. per ton. There are 83 furnaces in blast in Scotland, compared with 84 last week, and 77 at this time last year.

Pig Iron Shipments.

The shipments of pig iron from Scottish ports in the past week amounted to 4944 tons, compared with 5442 in the corresponding week. To the United States 500 tons were despatched, Canada 50, South America 15, India 184, Australia 780, Italy 180, Germany 20, Holland 190, Spain and Portugal 135, other countries 832, the coastwise shipments being 1753 tons, against 4243 in the same period of last year. The arrivals at Grangemouth of pig iron from Cleveland and district were 9715 tons, being 3982 tons more than in the corresponding week of 1908.

Finished Iron and Steel.

During the last few days steelmakers have been receiving more orders for steel plates for shipbuilding purposes, and the extra work has provided steadier employment at several of the principal works. An increasing inquiry is also reported for boiler plates both for home use and export. On the other hand, the demand for structural steel seems to have fallen away to some extent, but the demand for thin sheets is still satisfactory. There is a good deal of idle time at some of the works, but it is hoped that the turn of the year may bring a more satisfactory state of employment. There is no improvement whatever in the malleable iron department.

The Coal Trade.

For several days this week Glasgow and the Clyde have been enveloped in thick fog, which caused great interruption to traffic both by rail and water. A scarcity of coal for shipment and home use has been the temporary result, and prices have gone higher. House coal for shipment is quoted at Glasgow harbour 9s. 6d. to 10s. 6d.; steam coal, 9s. 9d. to 10s. 3d.; and splint coal, 10s. 3d. to 11s. per ton. The output of the collieries is large, and when the fog clears away there ought to be full supplies for all requirements.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Last Week's Coal Trade.

THE year will long be remembered in the annals of the coal trade for the continued evil influence of the weather. Last week was as bad as any experienced, and in addition to the injurious effect caused by delayed tonnage, several losses were sustained by Cardiff, and other shippers. One of these was that of a fine steamer laden with 3000 tons best steam consigned to Capetown. One of the consequences of delayed steamers was the large accumulation of stocks of coal. This at one time promised to result in a slump, but, fortunately, forward prices were stiff, and capital stems had been arranged up to Christmas, so the principal result was that in pressing cases buyers had a little more concession than usual, and the New Year does not promise badly as to existing contracts.

The White Star Line Contract.

This has been secured by Lewis's Merthyr Consolidated Collieries, and by Mann, George and Co. The price reported is

private, but previous fixtures have been 15s. 1½d. to 15s. 3d., and in the second case 14s. 10½d.

Latest Prices, Cardiff.

Still limited tonnage coming in, and prices not so firm, but forward business is well maintained. With fairer weather conditions colliery owners believe quotations will improve. Best large steam, 16s. 3d. to 16s. 6d.; seconds, 15s. 6d. to 16s.; ordinaries, 14s. 6d. to 15s.; best drys, 16s. 3d. to 16s. 9d.; best washed nuts, 13s. 6d. to 14s.; seconds, 12s. 6d. to 13s.; best washed peas, 12s. to 12s. 6d.; seconds, 10s. to 11s. 6d.; very best smalls, 8s. 6d. to 9s.; best ordinaries, 7s. 9d. to 8s.; cargo smalls, 6s. 6d. to 7s. 3d.; inferior sorts, 6s. to 6s. 6d.; very best Monmouthshire black vein, 15s. 3d. to 15s. 6d.; ordinary Western Valleys, 14s. 6d. to 14s. 9d.; best Eastern Valleys, 13s. 9d. to 14s.; seconds, 13s. to 13s. 3d. Bituminous coal: Best households, 17s. to 18s.; best ordinaries, 15s. to 16s.; No. 3 Rhondda, large, 17s. 3d. to 17s. 6d.; brush, 13s. 6d. to 13s. 9d.; smalls, 10s. to 10s. 6d.; No. 2 Rhondda, 12s. 9d. to 13s. 3d.; through, 9s. 6d. to 10s.; smalls, 7s. to 7s. 6d. Patent fuel, 15s. to 15s. 6d. Coke: Special foundry, 24s. to 27s. 6d.; foundry, 19s. to 20s.; furnace, 17s. to 17s. 6d.; pitwood, 20s. 6d. to 21s.

Newport, Mon., Coal.

No improvement for prompt coal. For forward bookings prices strong; smalls easy; pitwood advancing. Latest quotations:—Best black vein, 15s. to 15s. 3d.; Western Valleys, 14s. 3d. to 14s. 6d.; Eastern Valleys, 13s. 6d. to 13s. 9d.; other kinds, 12s. 6d. to 13s. 3d.; best smalls, 7s. to 7s. 3d.; seconds, 6s. 3d. to 6s. 9d.; inferiors, 5s. 9d. to 6s. 3d. Bituminous: Best house coal, 15s. to 15s. 6d.; seconds, 14s. to 14s. 6d. Patent fuel, 15s. to 15s. 3d. Coke: Foundry, 18s. to 19s.; furnace, 17s. to 17s. 6d. Pitwood, ex ship, 20s. to 20s. 6d.

Swansea Coal.

Little alteration shown, but a steady undertone. Demand for large coal good, machine-made coals firm, nuts and cobbles well maintained, beans scarce, rubbly culm firm, but duff weak. Latest:—Anthracite: Best malting, 23s to 24s. net; second malting, 21s. to 22s. net; big vein, 17s. 6d. to 19s., less 2½; red vein, large, 12s. to 13s., less 2½; machine-made cobbles, 23s. to 24s. net; Paris nuts, 25s. 6d. to 26s. net; French nuts, 26s. to 28s. net; German nuts, 25s. to 26s. net; beans, 18s. 6d. to 19s. 6d. net; machine-made large peas, 11s. to 12s. 6d. net; fine peas, 10s. 6d. to 11s. net; rubbly culm, 5s. 6d. to 5s. 9d., less 2½; duff, 2s. 6d. to 3s. net. Steam coal: Best large, 17s. to 18s.; seconds, 14s. 6d. to 15s.; bunkers, 9s. 6d. to 10s. 6d.; small, 7s. to 9s., all less 2½. Bituminous: No. 3 Rhondda, large, 18s. to 18s. 6d., less 2½; through, 14s. 9d. to 15s. 6d., less 2½; small, 10s. 3d. to 10s. 6d., less 2½. Patent fuel, 13s. to 13s. 6d., less 2½. Coal quotations all f.o.b., cash 30 days.

North's Navigation.

The settlement of the wages arrangements at these collieries appears to have been of a satisfactory character. The firemen have agreed to an advance equivalent to 5s. per week, the same to continue for five years.

Iron and Steel.

Dowlais continues to afford the most promising prospect in the district, though at Swansea a fair output of steel bars is taking place at Baldwin's. At Dowlais there was increased activity shown, and a more general briskness was apparent. Mills were busy, and the output of tin bar, billets, fish-plates, and colliery and heavy rails well up to the mark. It was to be noted, too, that while heavy rails were turned out for colonial orders, railway items were still insignificant. For the Colonies sleepers were again in request, and the accompaniment of rail cargoes from Newport continues to be large, quantities of coke showing that the works in India are active. The sleepers were despatched *vid* Manchester and Liverpool, and gave a total of 2100 tons. Sheet iron is being sent largely to Bristol from Newport. Welsh slag is in demand, and cargoes are being despatched to Ghent and Antwerp. Of basic slag little, if any, remains in stock, but of blast furnace there is abundance in the vicinity of the large works, though an authority observes that the varied quality of the ores used has resulted in a lack of uniformity with the slag, and is thus unfavourable to the manufacture of the best cement. Experiment may be useful in amending this opinion. Latest prices Swansea were as follows:—Pig iron hematite mixed numbers, 60s. 6d. cash and month; Scotch, 56s. cash and month; Middlesbrough, 50s. 7d. cash, and 50s. 11d. month. Welsh hematite, 66s. to 67s. 6d. delivered. Steel bars: Siemens, £4 15s. to £4 16s; Bessemer, £4 12s. 6d. to £4 15s. Iron ore, 16s. 6d. to 17s., Cardiff and Newport, Mon.

Tin-plate.

Operations last week at the Swansea tin-plate works were as satisfactory as they have been at any time of the year. The quantities received during the week totalled over 100,000 boxes. The precise totals were 102,990 boxes, and the shipments, 91,529 boxes, would have been larger but for the stormy weather, which proved so detrimental to all industries. Stocks now consist of 88,190 boxes. Loading will very likely be busy for the Baltic and Mediterranean ports, and cargoes for America fully up to average. At Llanelly the tin-plate trade was reported good, but rather quiet, and makers expect a brisk demand in the New Year. Latest prices:—Ordinary tin-plates, Bessemer and Siemens, I.C. 20 × 14 × 112 sheets, 12s. 4½d. to 12s. 6d.; ternes, 22s.; C.A. roofing sheets, £8 10s. to £8 15s.; big sheets for galvanising, £8 10s.; finished black plates, £9 10s. to £9 15s.; galvanised sheets, 24 g., £11 per ton; wasters, usual reductions. Block tin, £144 5 cash, £146 three months. Other quotations, Swansea:—Copper, £59 cash and £60 2s. 6d. three months; lead, English, £13 7s. 6d.; Spanish, £12 17s. 6d.; spelter, £23; silver, 23½d. per ounce.

Swansea Valley Industries.

Operations were briskly carried on at the copper and spelter works. The Mannesmann worked full time. Swansea Safety Fuse Company's plant well employed. Nickel's silver works maintain a good steady repute, and the leading foundries are all well placed for business.

Port Talbot.

There was a slight decrease in the port business last week. In the imports 2533 tons pig came in and 200 tons rails.

NOTES FROM GERMANY, FRANCE, BELGIUM, &c.

(From our own Correspondent.)

Rheinland-Westphalia.

The general condition of the market is firm and confident. Dealers have purchased heavily during the past few weeks; the mills and factories being well supplied with work for many weeks ahead, can await the further development of the market without feeling compelled to take in work at any price. Up to the present rates have shown considerable firmness. The sales of the Steel Convention during October of this year were 420,894 t., as compared with 438,904 t. in September, and as against 414,644 t. in October, 1908. This shows deliveries to have been 18,010 t. lower than in September of this year, and 6250 t. higher than in October, 1908. Of the deliveries in October of this year 133,775 t. were semi-finished steel, as compared with 136,487 t. in September, and as against 142,673 t. in October, 1908; railway material 158,112 t., as compared with 165,225 t. in September of this year, and as against 161,374 t. in October, 1908; sectional iron 129,007 t., as compared with 137,192 t. in September of this year, and 110,597 t. in October, 1908. Sales of the Wire Convention in October were nearly 32,000 t., more than one-third being for foreign consumption. At the end of last week the mills had orders on their books for 75,000 t.; prices for next year will be finally fixed at a meeting that is soon to take place.

List Quotations.

Official accounts from the Düsseldorf 'Change on November 25th stated current rates to be as follows:—Spathose iron ore, M. 10.90; roasted ditto, M. 15.50; Nassau red iron ore, 50 p. cent. contents, M 11 50 p.t. at mines; spiegeleisen, 10 to 12 p. cent. grade, M. 60 to M. 63; white forge pig, Siegerland and Rhenish-Westphalian quality, M. 55 to M. 58; iron for steel making, M. 56 to M. 58; German Bessemer, M. 58 to M. 60; basic, free place of consumption, M. 49 to M. 52; Luxemburg forge pig, M 46 to M. 48; Luxemburg foundry pig No. 3, free Luxemburg, M. 51 to M. 52; German foundry pig No. 1, M. 59 to M. 61; No. 3, M. 58 to M. 60; German hematite, M. 63; bars, M. 100 to M. 104; in some cases, M. 108; heavy plates, M. 110 to M. 115; boiler plates, M. 120 to M. 125; sheets, M. 122 to M. 125; hoops in basic, M. 122 50 to M. 125; drawn wire in iron and steel, M. 127.50, all per ton at works.

The Silesian Iron Market.

Reports continue favourable as regards the business in iron and steel. According to the *Rhenish-Westphalian Gazette* the Silesian Union for Steel Castings has been prolonged till October 1st, 1910; from the 15th November of this year the Union has reduced the prices for some articles 7½ per cent. Though Westphalian competition is keen, employment is stated to be satisfactory at all the principal establishments.

No Change in Coal.

Concerning the trade in coal and coke, last week's accounts can only be repeated. In Silesia more life was felt in consequence of the cold weather, and the sugar mills have also bought freely. For coke an increase in demand could be felt, both for engine and house fuel. Quotations are the same as before, M. 11 to M. 12 p.t. being quoted for gas coal, producer coal fetching M. 13.25; steam coal stands at M. 10 to M. 12.35, and coal for coke making at M. 11 to M. 12 p.t.; dry sorts of coal fetch M. 9.50 to M. 10.50, and anthracite No. 2, M. 21 to M. 24; foundry coke stands at M. 17 to M. 19 p.t., while blast furnace coke can be bought at M. 14 50 to 16.50 p.t. For briquettes M. 10.50 to M. 13 75 p.t. is given.

Austria-Hungary.

Only small purchases have been made in iron and steel, and as the Railway Ministry has postponed a vast amount of work for various reasons, the outlook is not bright as regards employment. The tone of the market is somewhat weak in consequence of the slackening off in various branches, and makers often find it difficult to maintain prices. A regular and good demand exists for all sorts of fuel, and more firmness has been perceived of late. Steam and gas coal are best inquired for; Bohemian brown coal sells freely.

The Belgian Iron Market.

There is not much to relate of the iron and steel business. Pig iron remains somewhat quiet, and makers cannot realise more than 67f. p.t. for basic, while foundry pig moves between 61f. and 68f. p.t. Consumption increases steadily. While the output in pig iron rose 335,000 t., import increased from 339,063 t. to 392,959 t. Stocks are small in all sorts of pig iron. There is no extensive business being done in bars, but current rates are well maintained; for home consumption a rise of 5f. p.t. to dealers has been resolved upon. Plate makers give rather good accounts, exports being particularly good, and figures are higher than last year. For girders the export price of £5 4s. is only nominal, and in rails only a poor trade was done. Both engine and house coal are reported in rising demand. For briquettes also some fair inquiries have come in from abroad, but this has not had any influence on prices. Exports in pit coal rose to 4,255,919 t. during the first ten months of this year, as compared with 3,913,048 t. in the same period last year. Imports rose from 4,446,593 t. to 4,794 710 t. Accordingly, import was 538,791 t. higher than export. From Germany 2,734,831 t. were imported to Belgium, as compared with 2,360,651 t. last year. In coke 842,460 t. were exported and 254,502 t. imported, 218,302 t. coke coming from Germany.

AMERICAN NOTES

(From our own Correspondent.)

New York, December 1st.

An unexpected weakening developed in pig iron from southern furnaces because of the throwing on the market in the central west of large quantities of Alabama iron. It is improbable that this action will have a permanent effect upon the market. Legitimate demand still in abeyance will probably absorb all available iron. Furnace output will be materially increased by next spring. Eastern railroads have about completed their requirements for steel rails, but western systems are still in the market. The Havana Central will buy 1200 tons of rails this week. The American Car and Foundry Company and the Standard Steel Car Company have each booked an order for 1000 coal cars from the Reading Railroad. In the nail industry activity prevails for both cut and wire nails, wire nails, of course, taking the precedence. The factories are accumulating stock. The Pennsylvania Railroad will largely add to its shop repairing facilities at Terre Haute, Indiana.

Billets are arriving at Atlantic ports from abroad, but as yet no orders have gone from Pittsburg, though the possibilities of such a course are still contemplated. The actual situation regarding the supply of crude steel in the west is not known. Some speculative influences have been quietly operating for months past, but these influences will not accomplish their intended purpose. Productive capacity is being expanded with all possible speed. The policy of maintaining prices at a dead level year in and year out, as has been successfully done in steel rails, will be applied as far as is possible to do so in all other mill products of wide consumption. Purely speculative efforts will be discouraged and crushed out. Mills everywhere are adding to their capacity, so that there will be no occasion for the annoying ups and downs in prices which have characterised the American iron and steel industry. In the copper market prices remain about stationary. The larger consumers are not in the market at present. The only thing worth noting is some speculative buying to protect the market. The talk of a giant copper merger is still the absorbing subject in mining and financial circles. The decision of the United States Circuit Court in declaring the Standard Oil Company an illegal corporation is deterring those who have in hand the formation of the great copper combination. That there will be some sort of a combination may be granted. The case will go to the Supreme Court for final adjudication.

LAUNCHES AND TRIAL TRIPS.

Risby, steel screw steamer; built by the Laxevaags Engineering and Shipbuilding Company, of Bergen; dimensions, 229ft. 6in. by 35ft. by 16ft. 10in.; to carry 1775 tons; engines, triple-expansion, 16in., 25½in. by 3in., pressure 175 lb.; constructed by the builders; trial trip, November 2nd.

Natalia, steel screw steamer; built by Swan, Hunter and Wigham Richardson, Limited; to the order of the Lineas de Vapores Serra, of Bilbao, Spain; dimensions, 290ft. by 42ft. beam; to carry 2250 tons; engines, triple-expansion; constructed by the builders; trial trip, November 6th.

Bassam, steel screw steamer; built by Irvine's Shipbuilding and Dry Docks Company, Limited; to the order of Elder, Dempster and Co.; dimensions, 355ft. by 46ft. by 25ft. 3in.; engines, triple-expansion, 25in., 40in., 67in. by 4in. stroke, pressure 180 lb.; constructed by Richardsons, Westgarth and Co.; trial trip, November 13th.

Gladys, steel screw steamer; built by the Goole Shipbuilding and Repairing Company, Limited; to the order of The Borneo Company, London; dimensions, 160ft. long; engines, compound, constructed by Richardsons, Westgarth and Co., Limited; launch, November 13th.

Cloutsham, steel screw steamer; built by W. Doxford and Sons, Limited; dimensions 378ft. by 51ft. by 30½ft.; to carry 8000 tons; launch, November 16th.

Steam launch Hall; built by Edward Finch and Co., Limited; to the order of the Corporation of Bridgewater; dimensions, 62ft. by 14ft. by 6ft.; constructed by W. and F. Wills; launch, November 16th.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

Messrs. Blake and Scott, of 41, Old Queen-street, Westminster, S.W., inform us that they have been appointed the representatives in London of Wm. Arnott and Co., of Coatbridge, for bridge and steel construction work.

Mr. D. R. Mayhew has resigned his position as branch manager to Willans and Robinson, Limited, in order to take up the position of general manager to Michael Pal and Co., Engineers, Westminster.

The Midland Institute of Mining, Civil, and Mechanical Engineers.—A general meeting of the members of the Institute will be held at the Arcade Hall, Barnsley, on Wednesday, December 15th, at 3.30 p.m. There will be a council meeting at 3 p.m. The following papers will be read:—"Automatic Protection Switchgear for Colliery Work," by Mr. E. B. Wedmore. "An Improved Instrument for Recording the Working of Winding and Other Engines," by Mr. A. Victor Kochs. The following papers will also be open for discussion:—"Recovery of Power from Exhaust Steam," by Mr. W. M. Sanderson. "Electricity in Coal Mines," by Mr. Robert Nelson.

The Institution of Civil Engineers: Students' Meetings.—At the Students' Meeting held at the Institution on Friday, the 3rd December, 1909, at 8 p.m., Col. R. E. B. Crompton, C.B., M. Inst. C.E., in the chair, Mr. George Ingram, Stud. Inst. C.E., read a paper on "The Design of Generating Stations." The author, having discussed at length the conditions influencing the choice of plant, went on to describe a suggested arrangement of plant for a shipyard, and for a large high-tension alternating-current station suitable for a bulk supply scheme. The author concluded by showing a number of lantern slides of various generating stations. An interesting discussion followed, in which the following gentlemen took part:—Messrs. C. J. Guttmann, E. Timothy, E. H. Spence, W. G. Fairweather, G. Lees, N. Smith, W. H. Pirrie, T. H. Williams, F. F. Arroya y Caso, H. G. Butchart, and W. D. Pile.

Contracts.—Ed. Bennis and Co. have recently received orders for seventy stokers and furnaces of various types, twenty-nine of which are the firm's high duty smokeless, smutless, and gritless, coking stokers.—The contract for laying water mains and building a pumping station and covered storage reservoir for the Pewsey Urban District Council has been awarded to Geo. Pollard and Co., Taunton.—A. and J. Main and Co., Limited, have just completed the final shipment from their Glasgow works of two important contracts for South America. One comprises about two-thirds of the steel-framed shedding, covering an area of 60,000 square metres, to be used in the housing of the coming Exhibition at Buenos Aires. The other being the complete roofs to cover in the filter beds of the city of Buenos Aires water supply, amounting to about 7½ acres area. This latter contract is being erected complete at destination by A. and J. Main and Co., Limited. This firm is also responsible for the erection in India of the whole of the steel buildings for the new rolling mills of the Tata Iron and Steel Company, housing the first iron and steel plant now being laid down in India for the production on a large scale of iron and steel from native ore.

The Institution of Electrical Engineers.—The members of this Institution held their annual dinner on Wednesday, December 8th, in the Hotel Cecil, London. Dr. Gisbert Kapp, the President of the Institution, occupied the chair, and two hundred and fifty gentlemen were present. Sir William H. White, K.C.B., F.R.S., proposed the toast of the Institution, and, in reply, Dr. Kapp made some interesting remarks on the present position of electrical enterprise in this country. He entered a strong protest against a growing habit of deploring British backwardness in adopting and developing electrical methods of working, and added that a recurrence to an expression of this belief must have the effect of discouraging our manufacturers and others from adopting the means advocated. It was not true, he continued, that foreign nations now held the lead in the electrical industry. While we had, perhaps, been backward in adopting some of the methods and inventions of the Continent, there were many discoveries and new processes which owed their inception to the genius and industry of British electricians, and at no time in the history of electrical science had there been greater activity in this country than at present. Prof. Sylvanus P. Thompson, F.R.S., in the absence through illness of Lord Justice Fletcher Moulton, spoke on the subject of science and industries, and, in reply, Sir Joseph Larmor, F.R.S., and Mr. J. A. F. Aspinall acknowledged the toast on behalf of the scientific and industrial worlds respectively. Among others present were the Rt. Hon. Lord Strathcona, Sir John Gavey, C.B., and Mr. C. E. Spagnoletti.

Royal Institution.—A general monthly meeting of the members of the Royal Institution was held on Monday afternoon—the 6th instant—Sir J. Crichton Browne, Treasurer and Vice-president, in the chair. Mr. J. H. Batty, Mr. T. Gibson Bowles, Mr. C. Broadbent, Captain F. S. Rose, Dr. H. Spitta, Mr. J. B. R. Swan, and Mr. J. S. Wilson were elected members. Geh. Reg. Professor Dr. Otto N. Witt, President of the Chemical Society of Berlin, and Professor George E. Hale, Director of the Mount Wilson Solar Observatory of the Carnegie Institution, Washington, were elected honorary members. The following are the lecture arrangements at the Royal Institution before Easter:—Mr. W. Duddell, a Christmas course of six illustrated lectures on "Modern Electricity, adapted to a Juvenile Auditory": (1) "First Principles;" (2) "Electrical Instruments;" (3) "Röntgen Rays;" (4) "The Generation of Electricity;" (5) "Electric Oscillations;" (6) "Electric Lighting." Professor W. A. Herdman, three lectures on "The Cultivation of the Sea;" Rev. C. H. W. Johns, two lectures on "Assyriology;" Professor F. W. Mott, Fullerian Professor of Physiology, R.I., six lectures on "The Emotions and their Expression;" Major Martin Hume two lectures on "Europe's Debt to Mediæval Spain;" Professor Silvanus P. Thompson, three lectures on "Illumination, Natural and Artificial;" Mr. A. J. Finberg, two lectures on "Turner;" Dr. H. Walford Davies, three lectures on "Music in Relation to other Arts;" Professor Sir J. J. Thomson, Professor of Natural Philosophy, R.I., six lectures on "Electric Waves and the Electro-magnetic Theory of Light." The Friday evening meetings will commence on January 21st, when Professor Sir James Dewar will deliver a discourse on "Light Reactions at Low Temperatures." Succeeding discourses will probably be given by the Rev. Canon Beeching, Professor W. Bateson, Mr. C. E. S. Phillips, Professor H. H. Turner, the Rt. Hon. Lord Rayleigh, Dr. Charles Chree, Dr. H. Brereton Baker, Professor Sir J. J. Thomson, and other gentlemen.

BRITISH PATENT SPECIFICATIONS.

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

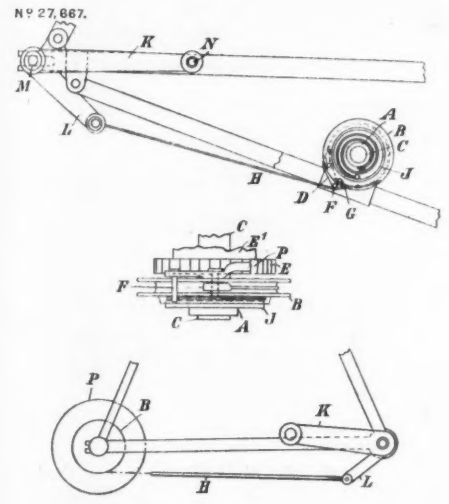
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-office of opposition to the grant of a Patent.

INTERNAL-COMBUSTION ENGINES.

27,667. December 19th, 1908.—IMPROVEMENTS IN OR CONNECTED WITH STARTING DEVICES FOR INTERNAL COMBUSTION ENGINES OF MOTOR BICYCLES, Alfred Angas Scott, of Mornington Works, Grosvenor-road, Bradford.

This invention has for its object improvements in starting devices for internal combustion engines of motor bicycles whereby the engine can be started by the rider when on his seat. As shown in the upper engraving, the boss A of the pulley B is mounted on the same shaft C as the two-speed gear, while the pawl D is arranged to engage with the teeth of a ratchet E fixed to a portion E^1 connected to the high gear chain wheel. This pawl D is mounted on the side of the pulley, and has a projection F on its backward extension projecting out therefrom at right angles and through a cut G in the groove of the pulley into the groove itself in such a way that when the flexible connection is wound round the pulley by means of the helical spring J it

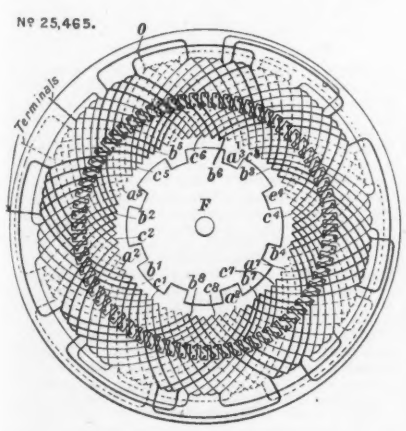


engages with the projection F and normally keeps the tooth of the pawl out of engagement with the ratchet. The flexible connection, which is of stranded wire or chain, is connected to a bell crank lever, the arms K and L of which are at about 45 degrees to one another, mounted on the rear wheel spindle M. The free arm K of the bell crank lever is provided with a crank or pedal N, so as to be capable of being engaged and pressed down by the foot of the rider. The pedal is normally kept in its raised position by the helical spring J of the pulley. As will be seen, the above arrangement is particularly applicable to machines with clutches enabling the engine to run free, or with variable gears with a position enabling the engine to run free. In the cases, as in the lower engraving, in which the free engine clutches P are arranged on the back wheel intermediate to the belt pulley or sprocket wheel and the driving wheel, the starting pulley may be arranged at the back and the starting lever in the position generally occupied by the pedals if such are not used.—*November 27th*, 1909.

DYNAMOS AND MOTORS.

25,465. November 25th, 1908.—IMPROVEMENTS IN AND RELATING TO ALTERNATING-CURRENT DYNAMO ELECTRIC MACHINES, the British Thomson-Houston Company, of 83, Cannon-street, E.C.

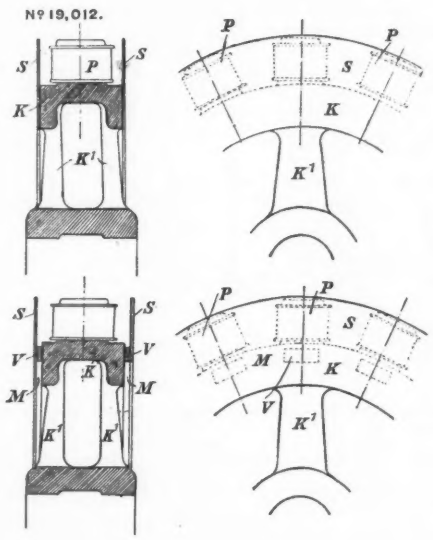
This invention relates to alternating-current dynamo electric machines, and its object is to provide a novel and simple form of armature winding whereby a true sine wave of induced electro-



motive force is attained. F represents the field magnet, with eight poles. The armature is shown with 72 slots, 9 per pole, and has a three-phase winding of three coils per pole per phase. The several phases are indicated by lines of different characters, and lettered *a*, *b*, *c*. The three phases have a common terminal O. The three phases are then connected in Y, so that between each pair of terminals the third harmonic and its overtones are eliminated. Each coil spans seven slots, or, in other words, has a pitch of $\frac{7}{9}$. Since this is approximately equal to $\frac{4}{5}$, the fifth harmonic is substantially eliminated in each coil. While the total number of coils of each phase is 24, that is, three per pole, the coils of each phase are not grouped in the usual manner. The groups of coils at the several poles differ in the number of coils per group. For instance, considering the phase shown in heavy full lines, to which reference letters *b* are applied, exponents being used to denote the different groups, it will be seen that starting at group b^1 and proceeding in a clockwise direction around the armature the number of coils in the groups are as follows:—b^1, 3 coils; b^2, 4 coils; b^3, 3 coils; b^4, 2 coils; b^5, 3 coils; b^6, 4 coils; b^7, 3 coils; and b^8, 2 coils; that is, groups b^2 and b^4 each have one coil in excess, while groups b^6 and b^8 have a deficit of one coil each. The result of this grouping of coils is to displace half the coils of the phase from the other half. For instance, considering groups b^1 and b^5, it will be seen that the coils in these two groups instead of being displaced by 18 slots—that is, twice the pole pitch—are displaced from each other by 19 slots. In other words, the two groups of coils are offset from each other by a slot—that is, by $\frac{1}{9}$ of the pole pitch. Similarly, groups b^2, b^3 and b^4 are offset from groups b^6, b^7 and b^8 respectively by one slot. In other words, half the coils of the phase are offset from the remaining coils of the phase $\frac{1}{9}$ the pole pitch, and this offset, as has heretofore been explained, results in the substantial elimination of both the seventh and the eleventh harmonics. The theory of the winding is fully described.—*November 17th*, 1909.

19,012. November 11th, 1909.—IMPROVEMENTS IN THE ROTORS OF DYNAMO ELECTRIC MACHINES FOR REDUCING NOISE, Siemens Brothers Dynamo Works, Limited, of Caxton House, Tothill-street, Westminster.

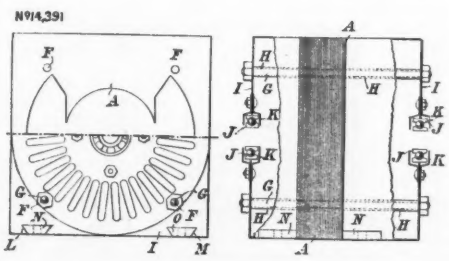
Referring to the upper engravings, the salient poles are denoted by P, the magnetic yoke by K, and the spokes by K^1. The yoke K projects sidewise to some extent on either side beyond the poles P, and according to the invention discs S are screwed to the sides of K. The outer diameters of the discs S are nearly or exactly equal to the outer diameters of the poles P, and the latter are consequently nearly or completely enclosed in a ring-shaped canal. A moderate movement of air around the pole or rotor windings is desirable for cooling purposes, but usually when the discs are



fitted there will be a sufficient movement for this purpose owing to the production of weak eddy currents of air due to air friction against the inner cylindrical stator surface. When, however, a sufficient movement of the air for cooling purposes is not obtained in the above manner distance pieces may be fitted between the yoke K and the discs in order that a limited quantity of air may flow into the ring-shaped canal through the spaces between the yoke and the discs. The foregoing arrangement with distance pieces is illustrated in the lower engravings, which are similarly lettered. In the former figures projections or distance pieces V are fixed between K and S, and a limited quantity of air flows through the narrow ducts M so produced in a radial direction into the ring-shaped canal. This air circulates in the ring-shaped canal and cools the windings of the poles P sufficiently without producing any undue noise.—*November 17th*, 1909.

14,391. June 19th, 1909.—IMPROVEMENTS IN DYNAMOS OR ELECTRICAL MOTORS, John Halifax Garty, of 51, Bishop-street, Anderston, Glasgow, Scotland.

The object of this invention is to simplify and cheapen the construction of dynamos and motors. The magnetic field and yoke parts are constructed of a series of stamped metal plates provided

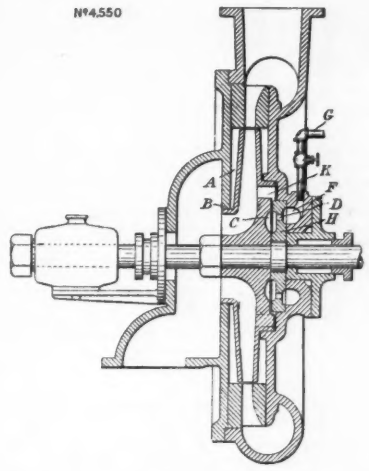


with one or more pairs of poles, with suitable holes to receive bolts supporting the end plates, which are of stamped metal and the requisite key-ways to take the bars constituting the feet. The yoke and magnetic field portion A, which is composed of a series of stamped metal plates of square section outside, is provided with one or more pair of poles. Holes F are formed for the reception of the bolts G, the bolts have fitted thereon the tubular distance pieces H for bracing together the end plates I, I which carry the bearings J, J for the spindle of the dynamo or motor—not shown. Suitable shields K envelope the bearings, as seen. The stamped metal plates composing the yoke and magnetic field A are provided with the dovetail key-ways L, M designed for the bars N, O which constitute feet for enabling the dynamo or motor to be bolted down to the place required.—*November 17th*, 1909.

PUMPING AND BLOWING MACHINERY.

4550. November 11th, 1909.—IMPROVEMENTS IN BALANCING DEVICES FOR CENTRIFUGAL PUMPS AND THE LIKE, *Henry R. Worthington, No. 115, Broadway, New York.*

The chambers A extend from the outer edge of the impeller inward to the running joints which are formed between shoulders on the impeller, and on the casing. Instead of making these chambers A of the same radial dimensions as usual, the chamber on one side, and preferably the front or suction side of the impeller, is made of greater radial dimensions than that on the other side of the impeller, so that a larger surface on the impeller is exposed to the pressure in the chamber A on the suction side of the impeller, thus securing a constant excess of pressure tending to move the

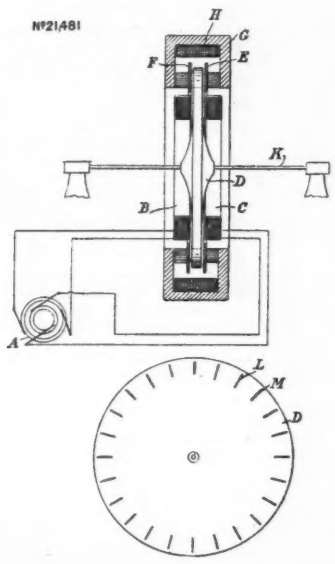


impeller to the right in the drawings. At the back of the impeller is a balancing chamber C which connects through passages D with a circular chamber F in the casing, into which liquid under the desired pressure is introduced through pipe G, controlled by a cock by which the normal pressure on the rear side of the impeller opposed to the constant excess of pressure on the other side may be regulated as desired. In the construction shown, the chamber C is enclosed by the bearing surfaces on the back of the impeller and the thrust bearing ring H, and the space outside the bearing surfaces is connected with the impeller by passages K through the impeller. The liquid from pipe G thus passes between the bearing surfaces to the impeller and forms a liquid anti-friction bearing. The circular chamber F is not essential, but any suitable connection constructed to supply liquid to chamber C and the liquid bearing may be used.—*November 17th*, 1909.

TELEGRAPHS AND TELEPHONES.

21,481. October 10th, 1908.—IMPROVEMENTS IN DRIVING SHAFTS ELECTRICALLY AT HIGH SPEEDS, *Reginald Aubrey Fessenden, of Brant Rock, State of Massachusetts, United States of America.*

The upper engraving shows the method as applied to the driving of a high-frequency alternator. Here A is a two-phase dynamo having a frequency of 500 cycles per second; B, C is the field of the motor; D is the armature of the motor and may consist of a single disc of phosphor bronze or nickel steel. A side elevation of



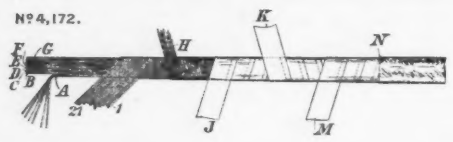
this disc is shown in the lower engraving. E, F are the armatures of the high-frequency machine to be driven; G is the field circuit, and H the magnetising coil for the field circuit of the high-frequency machine; K is a shaft on which the motor armature or rotor is mounted. The disc D is slotted around its circumference, and the slots L, M are filled with pieces of thin sheet iron in order to complete the magnetic circuit of the high-frequency alternator. By means of this apparatus a rotative speed of 30,000 per minute can be maintained, with a minimum of frictional loss and of vibration.—*November 17th*, 1909.

TRANSMISSION OF POWER.

4172. February 20th, 1909.—IMPROVEMENTS IN INSULATED WIRE CABLES, British Insulated and Helsby Cables, Limited, Milton-road, Edge-lane, Liverpool, and William Aitken, of the same address, and Charles Randall Sproule, of the British Insulated and Helsby Cables, Limited, Helsby.

This invention relates to the construction of insulated wire cables, and primarily to those used for telephone switchboard construction work. In the form of cable generally used for this purpose three wires are twisted together for each circuit, and twenty-

one such triple wires are laid up round a cardboard core or centre. The cardboard core is required to give a rigid base on which to lay up the wires, which are afterwards pressed flat, and kept flat by this cardboard centre. The objections to this method of construction are: (*a*) That the signalling wire is laid up with the speaking circuit, and inductive disturbances are liable to be set up in the latter; (*b*) the cardboard centre absorbs and retains moisture readily, and although this may be removed when the cable is manufactured, the moisture is re-absorbed when the cable is cut up into lengths for forming into multiple jack ends; (*c*) the cable is bulky. The present invention overcomes the objections specified in the following manner:—The twenty-one pairs are laid up

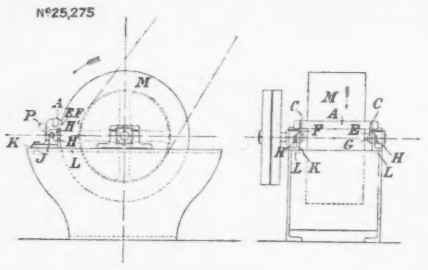


in seven cables of three pairs, as shown at A to G. Each set of three pairs are stranded together with a suitable lay. The seven small cores are laid side by side, and during the process of manufacture are passed through a thin metal flattened tube, which acts as a former to keep these cables in a flat formation, and takes the strain from the lay-up of the wires which are to be wrapped round the seven cores, and this former therefore prevents the seven cores being displaced from the flat formation. The twenty-one single wires for the signalling circuits are arranged twenty-one wide, and are lapped round the seven cores with a suitable lay, as shown at 1 to 21. The cable thus formed is lapped with a cotton covering H, paraffin paper J, lead foil K, another lapping of paraffin paper M, and then braided N in any of the well-known manners.—*November 17th*, 1909.

MACHINE TOOLS AND SHOP APPLIANCES.

25,275. November 24th, 1908.—IMPROVEMENTS IN TOOL RESTS FOR GRINDSTONES AND ABRADING MACHINES, Manasseh Luney, Farm Cottage, Whitehouse, Antrim, Ireland, and James Charles Hamilton, Sunnyside, Whitehouse, Antrim, Ireland.

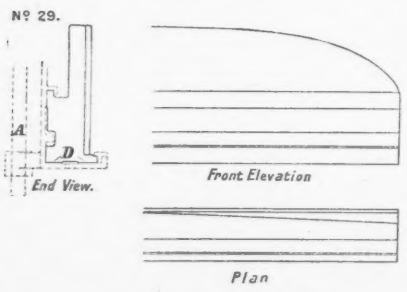
This invention relates to an improved tool rest for grindstones and abrading machines, of the kind which automatically alters its position in relation to the abrading surface, if by accident the tool or article to be ground gets between the tool rest and the abrading surface of the grindstone or abrading machine. The invention essentially consists of a bar, A, on which the tool or article to be ground is rested, the bottom side of which is notched at the two studs C, C, and fitted into complimentary notches in the top of the two brackets E, F, which are free to swivel on two studs G, G, and stopped by projections H, which retain the brackets E, F and bar



A in a normal position when in use. The portion of the brackets E, F which swivel on the two studs G, G is made in the form of a slot J, with one end open, and thus make a simple arrangement, and facilitate the purpose of cleaning, as the brackets E, F can be lifted off the studs G, G and the bar A, off the brackets E, F, without unscrewing any portion of the apparatus. The studs G, G are fixed in the upright portion of the pedestals K, K, which are bolted to the framing L of the grindstone M or abrading machine, and the projections H, H, for stopping or retaining the brackets E, F and bar A in a normal position, are cast on or screwed to the brackets E, F. If the tool or article to be ground accidently gets between the bar A and abrading surface of the grindstone or abrading machine M, the distance of the bar A is automatically increased, as shown by the dotted lines at P and H1.—*November 17th*, 1909.

29. January 1st, 1909.—IMPROVEMENTS RELATING TO RADIAL DRILLING MACHINES, Loudon Brothers, Limited, of Clyde Engineering Works, Johnstone, Renfrew, and Charles Francis Rush, also of Clyde Engineering Works, Johnstone, Renfrew.

This invention relates to a new type of radial arm for drilling machines, whereby a greater resistance is offered to the upward vertical thrust produced when drilling, also a greater resistance to



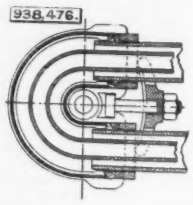
the torsional strain which takes place in an ordinary machine. These results are obtained by making the bearing faces on the under side of the radial arm to extend the full width across it, and thus offer a greater resistance against the upward vertical thrust, due to this thrust being distributed over a larger area than is usually the case. From the engraving it will be clearly seen that the vertical upward forces acting on this radial arm due to feeding the revolving spindle A into the material being operated upon will be distributed over the whole face D, and so over the whole width of arm, thus offering a greater resistance to vertical upward thrust and torsional strain.—*November 17th*, 1909.

SELECTED AMERICAN PATENTS

(*From the United States Patent-office Official Gazette.*)

938,476. CONDENSER, *C. J. A. Gottlieb, Aarhus, Denmark.—Filed May 28th*, 1908.

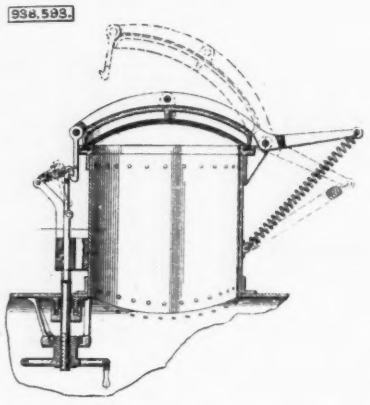
This patent is for the construction of what may be termed headers. Their construction will be best understood from the drawing. There are two claims. The second runs "in heat-exchanging apparatus, the combination with an outer and an



inner tube, of a divided curved connector forming a prolongation of the outer tube and provided with a shoulder on each of the divided parts, a pair of packing rings encircling the two outer tube ends, a packing joint between the two-part curved connector and the packing rings, a bolt engaging with the shoulder on the divided curved connector, and means co-operating with said bolt for tightening the joint between the rings and the divided curved connector."

938,593. WATER-TIGHT HATCH OR MANHOLE COVER, *M. A. Laubeuf, Paris, France.—Filed June 23rd*, 1909.

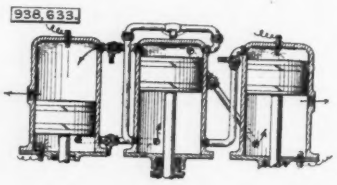
This invention applies to torpedoes and submarines. The



drawing makes the nature of the invention quite clear. There are ten claims.

938,633. INTERNAL COMBUSTION ENGINE, *Gustav V. Benson, Chicago, Ill.—Filed July 14th*, 1909.

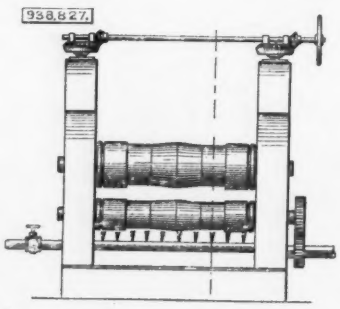
This patent is for the combination of one central compression



cylinder with two explosion cylinders. The compression or "pumping" cylinder is double-acting. There are four rather long claims.

938,827. STEEL CAR AXLE AND METHOD OF MAKING THE SAME, *Andrew C. Cunningham, Norfolk, Va.—Filed December 17th*, 1908.

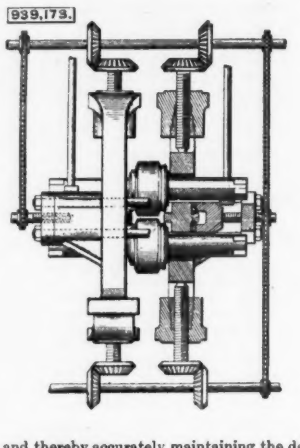
The invention claimed is a method of producing car axles of great hardness, toughness, ductility, and strength, which consists in first heating a billet or bloom of steel of the necessary size;



secondly, forming said bloom into a billet of elliptical or flattened cross section by rolling the same longitudinally; and thirdly, working and shaping said billet by cross or transverse rolling throughout its length under gradually increasing pressure. There are four claims.

939,173. UNIVERSAL ROLLING MILL, *H. Sack, Düsseldorf, Germany; A. Sack, Administratrix of said H. Sack, deceased.—Filed November 30th*, 1908.

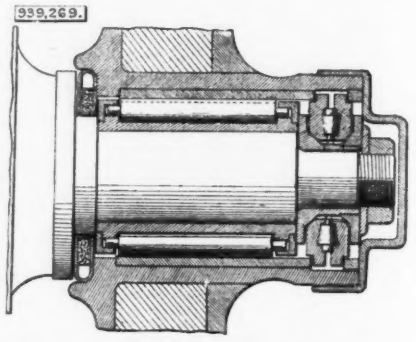
This is one of several patents taken by Herr Sack for improvements in rolling mills. This one is for a universal mill for rolling I-bars with outwardly diverging flanges, comprising a pair of housings having guideways, a pair of horizontal rolls journaled in bearings in said guideways, a pair of vertical rolls, each having a convex face, a pair of chocks carrying said vertical rolls, horizontal guideways for said chocks, and inter-connected means for simultaneously forcing both the horizontal and the vertical rolls toward



the roll pass, and thereby accurately maintaining the desired form of pass. There is only one claim.

939,269. THRUST BEARING, *A. T. Killian, Buffalo, N.Y., assignor, by direct and mesne assignments, to National Anti-friction Roller Bearing Company, Buffalo, N.Y., a Corporation of New York.—Filed March 5th*, 1909.

There are three claims. The third runs as follows:—In combination, a shaft and a rotatable hub thereon, a pair of rings surrounding the axle and having engagement therewith and also



with the hub, and having their adjacent faces provided with annular grooves and tracks whose faces are oppositely bevelled, a series of radially arranged thrust-receiving rollers, and a series of radially arranged spacing rollers smaller in diameter than the thrust rollers and having reduced end extensions running on said tracks, for the purpose set forth.

MACHINERY EXHIBITION IN MANCHESTER.—An exhibition of machinery is to be held next year in the new City Exhibition Hall at Manchester. Preparations for this exhibition are, we understand, in a forward state. The hall is fitted up especially for exhibitions of this character, the main gangways being paved with wood blocks, and being sufficiently strong to permit the safe passage along them of a 10-ton traction engine. Moreover, arrangements will be made for lifting heavy weights into position and for supplying power, water, &c. Particulars of the exhibition may be obtained from Mr. W. Cawood, 16, John Dalton-street, Manchester.

NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—A general meeting of the members of the North of England Institute of Mining and Mechanical Engineers will be held in the Wood Memorial Hall, Newcastle-upon-Tyne, at two o'clock, on Saturday, December 11th. The following paper will be open for discussion:—"Automatic Cage Tub-stops," by Mr. T. Campbell Futers, and the following papers will be read or taken as read:—"Some Results of Experiments made to Test the Effect of Sprayers upon the Moisture of Main Roads at Brandon Colliery," by Mr. T. L. Elwen; "Sinking the John Shaft at Hamsterley Colliery through Sand and Gravel by means of Under-hanging Tubbing," by Mr. John Cummings; "Electric Shot-firing," by Mr. James Douglas; and "A Natal Colliery Explosion, and Underground Fires in Fiery Mines," by Mr. Wm. Taylor Heslop. A new reinforced concrete mine prop will be exhibited and described by Mr. F. Elford Gulley, and a patent self-oiling colliery guide sheave will also be exhibited and described by Messrs. Jno. Alf. Jackson and Son.

THE TELEPHONE OPERATOR.—The telephone operator had hardly sprung into existence when the necessity for her services began to be contested by inventors, who within three years after the invention of the telephone itself proposed to provide each telephone user with means for establishing any desired connection himself without the aid of any operator. For years the automatic telephone was considered an improbability by the great majority even of the most skilful telephone engineers, and at the present time it is not unusual to find articles in telephone journals in which the idea of the telephone operator being done away with is held up to ridicule. But events such as those which have been recently taking place in Munich are in themselves sufficient proof that the idea of banishing the telephone operator from local exchanges at any rate, viz., exchanges in which the subscribers in one and the same city are inter-connected is by no means Utopian. During last month a considerable number of the telephone subscribers of Schwabing, a suburb of Munich, were transferred from the old manually-operated telephone exchange to a new automatic system. This system is, in the main, the one which bears the name of Strowger, who is one of the inventors who have developed a successful system which has been installed in many towns in America. The Munich automatic telephone exchange system is arranged for a capacity of 100,000 subscribers, and comprises five distinct groups of automatic switches called line switches or pre-selectors, first selectors, second selectors, third selectors and connectors. The system is a central battery one, *i.e.*, there are no batteries in the subscribers' instruments, all the battery power being centralised in the exchange. The whole town is to be ultimately provided with an automatic service, and the systems of other towns in Bavaria will, perhaps, also be converted to the automatic system. Several German firms are now developing automatic telephone systems.

NOTES ON THE DESIGN OF SHAFTS, WITH SPECIAL REFERENCE TO HIGH SPEED ELECTRIC GENERATORS.

By H. H. JEFFCOTT.

No. V.* *(conclusion)*

28. If the load on a shaft consists of discs (of external and internal radii a_1 and a_2), we may examine the rotational strains in them. At any point distant r from the centre of the disc the radial strain due to rotation may be shown to be

$$\lambda \cdot \left\{(3 - 2\sigma)(a^2_1 + a^2_2) - \frac{3 - 2\sigma}{1 - 2\sigma} \cdot \frac{a^2_1 a^2_2}{r^2} - 3r^2\right\},$$

and the tangential strain is

$$\lambda \cdot \left\{(3 - 2\sigma)(a_1^2 + a_2^2) + \frac{3 - 2\sigma}{1 - 2\sigma} \cdot \frac{a^2_1 a^2_2}{r^2} - r^2\right\},$$

The greatest strain is tangential and has the value

$$2\lambda(1 - \sigma)\left\{a^2_2 + \frac{3 - 2\sigma}{1 - 2\sigma} \cdot a^2_1\right\}.$$ The discs should be strong enough to withstand this strain. In particular, the discs of which an armature is built must be able to withstand this strain, in addition, of course, to the strains due to gravity, and the magnetic pull exerted on the iron by the field pole system. This last may be reckoned as $B^2_g A \times 8.942 \times 10^{-8}$ lb. weight directed to each pole, and spread nearly uniformly over that part of the armature surface under each pole; A is the air gap area in square centimetres, and B_g is the gap density in lines per square centimetre.

In the case of the shaft, which is continuous up to the axis, the rotational strains are:—

$$\text{Radial strain} = \lambda \left\{(3 - 2\sigma)\, a_1^2 - 3r^2\right\};$$

$$\text{Tangential strain} = \lambda \left\{(3 - 2\sigma)\, a_1^2 - r^2\right\}.$$

The greatest strain is tangential and of magnitude $\lambda(3-2\sigma)\, a_1^2$.

Comparing this with the solution for the disc load, in which we make the internal radius a_2 indefinitely small, we find that the greatest tangential strain in the latter case—in which the shaft has a small flaw along its axis—is greater than that when there is no flaw in the proportion $\frac{2(1-\sigma)}{1-2\sigma}$. In other words, if the shaft have a small flaw along its axis, the greatest rotational strain is about three times what it would be in a sound shaft.

Flexure alone—Factor of safety (for alternating load 3) = 3.

Torsion alone—Factor of safety (for flaw 2, for sudden reversal 3, for short circuit 3 or more) = 6 say.

Rotation alone—Factor of safety (for flaw 3, for sudden application of load 2) = 6.

If we multiply by a margin of 2, we find that a factor of safety of 6 to 12, depending on the nature of the load, will be sufficient. These figures are in accordance with common practice. As the elastic limit is about one-half of the ultimate strength, we see that the values of the factor of safety just given ensure that the working stress does not exceed the elastic limit.

30. As an example of the determination of whirling speed and factor of safety, we take the case of a 500-kilowatt continuous current turbo generator, 2 poles, 500 volts, 2400 revolutions per minute. Shaft diameter $5\frac{3}{4}$in. Distance between bearing centres 89in. $E = 39 \times 10^6$ lb. per square inch. $I = \frac{1}{4}\pi a_1^4 = 53.7$in. units. $g = 386$in. per second per second. G, the magnetic unbalanced load = 28,000in. lb. units. The value of ω^2 is first obtained by neglecting G, and then the value of $\frac{G}{\omega^2}$ is sufficiently known for a second approximation. See sections 14, 15.

Omitting G in a first approximation, we find $\Sigma\, q\, m\, \Psi - \Sigma\, q'\, m\, \frac{k^2}{l^2}\, \theta$ is ·3882. Also $3{\cdot}75\, \frac{E\,I}{l^3} = 11{,}400$; $\therefore\ \omega^2 = \frac{11{,}400}{.3882} = 29{,}300$. Hence $\frac{G}{\omega^2} = 1$ (nearly) for a second approximation. Adding the corresponding term to $\Sigma\, q\, m\, \Psi$ we obtain a value for ω^2 which gives $\frac{G}{\omega^2} = 1.14$ for a third approximation.

Thus finally we obtain $\omega^2\,(.4523 - .0082) = 11{,}400$; $\therefore\ \omega^2 = 25{,}750$; $\therefore\ \omega = 160.5$; N = 1525 revolutions per minute. Had we omitted G we would have obtained 1630 revolutions per minute.

The actual whirling speed was 1480 revolutions per minute when the machine was run, vibration occurring from about 1450 to 1520 revolutions per minute.

Using the second formula (section 14) in the same way we find $\omega^2 = 25{,}400$, $\omega = 159$, N = 1515 revolutions per minute.

If the whole load be imagined split up into, say, five pieces spaced along the shaft we may take

m =	1·30	4·19	1·31	1·33	1·78
l =	·135	·291	·45	·528	·865

Load.	Weight, lb.	Mass.	Square of radius of gyration about transverse axis (inch-units).	Position, inches from end.	Value of r.	Value of ψ.	Value of θ.	Value of q	Value of q^1.	$q\, m\, \phi$.	$\frac{k^2}{l^2} q^1 m \theta$.
Shaft	650	1.69	2.06	—	—	.0396	.3812	1	1	.0650	.00168
Commutator and rings	332	1.15	15.2	12	.135	.013	.61	1.1	1.15	.0165	.001550
		1.15	15.2	42	.472	.077	.01	1	2.8	.08 6	.000018
Cover, copper, and casting	393	1.02	40.3	49	.55	.076	.021	1	2.8	.0775	.000087
Core and teeth, copper, and separators	1067	2.74	29.0	63	.7.9	.048	.29	1.02	1.25	.1342	.002750
Cover, copper, and casting	393	1.02	40.3	77	.865	.013	.61	1.1	1.15	.0146	.003.40
$\frac{G}{\omega^2}$	—	1.14	—	63	.709	.048	—	1.02	—	.0559	—
										.4523	.008213

Further, if there is a flaw near the circumference, the greatest torsional strain may be twice that for a sound shaft. (Love, "Elasticity," vol. I., chap. VI.)

Again, a sudden application of a load may produce strains twice as great as the same load gradually applied would give; and a sudden reversal of load may produce strains three times as great as those due to the same load steadily applied.

There are also strains due to centrifugal and magnetic forces if the shaft is thrown into vibration, as well as strains due to torsional oscillation.

29. The proper factor of safety to allow in any given case will depend upon the relative magnitudes of flexural, torsional, and rotational strains.

If rotational strain greatly predominates a factor of safety of 3 will be required to provide against flaws (near the axis). If torsional strain predominates the factor of safety need only be 2. If flexural strain greatly predominates the factor of safety may be reduced to nearly one, so far as flaws are concerned.

Further, we are concerned with the nature of application of the various loads. For each load suddenly applied a factor of safety of 2 must be allowed on the corresponding strain, and for sudden reversal of load the corresponding strain should have a factor of safety of 3.

In the case of flexure of the rotating shaft under gravity the load is alternating, and a factor must be allowed on the ordinary breaking stress, say 3. The possibility of increased torsional load due to short circuit in the case of a dynamo should also be provided for by a factor of safety of at least 3.

It is to be remembered that if the load is not perfectly balanced the out of balance loads give rise to flexural strains.

Thus, in general, the total factor of safety demanded from the consideration of possibility of flaws, and nature of application of load depends on the relative magnitudes of the flexural, torsional, and rotational strains.

We may separate the following cases:—

and hence by sections 10, 11 we find $\omega^2 = 26{,}000$, $\omega = 161$, N = 1540 revolutions per minute.

If we require the second whirling speed roughly we may imagine the load divided into two parts: mass 4·385 at $l = \cdot 20$, and mass 4.385 at $l = .64$. Then by section 17 we find $\omega^2 = 29{,}350$ or $321{,}000$; $\therefore\ \omega = 171$ or 566; N = 1630 or 5400. These have still to be corrected for magnetic pull G. We find then N = 1525 or 5390. Thus G exerts a much smaller effect on the second than on the first whirling speed, since indeed $\frac{G}{\omega^2}$ is then smaller.

If we require the second whirling speed with greater accuracy we should take a distribution of load more nearly approximating to the actual, and follow section 17; or, take the load as actually distributed and assume a displacement curve coinciding with the actual curve at two suitable points. (See sections 13, 16.) And so on, for higher whirling speeds.

To determine the factor of safety (section 27) on greatest strain theory:—Normal speed 2400 revolutions per minute, $\therefore\ \omega = 252$; H = twisting couple = 17,600 inch lbs.; $\lambda = 1.21 \times 10^{-7}$; $\tau = 1.026 \times 10^{-5}$. For X let us take that load at the centre of the shaft that will give the same maximum bending moment as the maximum bending moment for the actual distribution; $\frac{1}{2}\, X \times 44{\cdot}5 = 47{,}500$; $\therefore\ X = 2140$ lb., $\mu = 1.12 \times 10^{-8}$. Hence $S' = 8.122 \times 10^{-5}$; $S'' = 8.022 \times 10^{-5}$; $S''' = 6.4 \times 10^{-5}$. Taking $T_o = 135{,}000$ lb. per square inch, we find $\Phi' = 41.6$; $\Phi'' = 42.1$; $\Phi''' = 52.9$. The shaft is more than amply strong, stiffness rather than strength being here the dominating factor.

It will be noticed too that the rotational stresses are small compared with the total stresses.

* No. IV. appeared December 3rd.

COMPOUND ENGINES.

By R. M. DEELEY, M. Inst. C.E.

The increasing use that is being made of compound locomotives, especially on the continent of Europe, cannot fail to make thoughtful railway engineers ask themselves how it is that they are so unpopular in England. The problem is a complex one, and can only be answered by the consideration of quite a number of circumstances. As I have had some considerable experience in the design and working of both simple and compound locomotives, I venture to put on record some facts which may be of interest.

In this country Mr. Webb and Mr. Worsdell were the first to experiment on a large scale. Their engines did and are now doing useful work on some of our lines. It is true that most, if not all, of Mr. Webb's engines have been broken up during recent years. There seems no doubt but that they were too small to work our modern trains, and that they frequently failed to start without assistance. Mr. Malcolm, however, has a number of compounds of the Worsdell-von Borries type at work in Ireland, and he considers them good and economical engines.

Although the feeling in England among railway men always has been, and still seems to be, strongly against compounding, when Mr. S. W. Johnson discussed the question with me, and stated that he contemplated building such an engine I strongly advised him to do so, more especially as the late Mr. W. M. Smith had designed a three-cylinder arrangement which promised to start away well with a heavy train under all conditions of load and gradient. There was quite a number of circumstances which led me to support the proposition.

The introduction of the corridor, dining, and sleeping coaches has largely increased the weight of the train to be hauled; for owing to the great restriction in seating space the corridors, lavatories, &c., entails, the weight of train per passenger has been much increased. These heavy trains frequently required more than one engine to draw them, a most expensive method of working, for two drivers and two firemen were then required. The weight of the engines alone was a large proportion of the train, and the consumption of fuel by the two engines was consequently very heavy. To increase the size of the cylinders and boiler very much meant heavy stresses on the connecting-rod bearings and other parts. Large bearings and heavy parts are not particularly objectionable on stationary engines, but on locomotives, owing to the flexibility of frames, wheels, &c., necessary to allow the locomotive to run round curves, wide bearings are very apt to run hot owing to the cross strains set up. The use of three cylinders and cranks enabled the crank and connecting-rods to be relieved of considerable strains, whilst the compounding promised to relieve the boilers very considerably.

The first five compounds built on Mr. W. M. Smith's plan, and now numbered 1000 to 1004, have two outside low-pressure cylinders and one high-pressure inside cylinder. With the first engine a large number of experiments was made to ascertain the best diameters of cylinder, the necessary end clearances to prevent undue compression, and the best ratio of cut-off and release of the high-pressure and low-pressure valves. The five engines were then completed. The two outside low-pressure cylinders have their cranks at right angles, and the crank of the high-pressure cylinder is on a line intermediate between the two outside cranks. As soon as steam is admitted to the high-pressure steam chest some of it passes through a reducing valve to the low-pressure steam chest, which then works as a simple engine under about 60 lb. of steam. To prevent excessive differences of pressure on the high-pressure piston when starting, a valve is fitted at each end of the high-pressure cylinder, so that should the pressure in the intermediate steam chest become greater than that in the high-pressure cylinder, the steam can pass it and balance the piston. Unless these valves are fitted I find that the locomotive will not start in certain positions.

These five engines worked so satisfactorily that I built forty others, to the drawings published in THE ENGINEER of March 9th and 23rd, 1906, for the fast heavy passenger service on the Midland Railway. They were, however, modified and simplified in some respects. Mr. Smith's high-pressure cylinder equalising valves were retained; but instead of passing steam through a reducing valve to the low-pressure steam chest when starting, it was admitted through a port in the jockey valve on the main regulator valve. The first movement of the regulator handle moves the jockey valve into such a position that steam is admitted to the high-pressure steam chest, and also by a separate port through an auxiliary small steam pipe to the low-pressure steam chest. The engine then starts away with full boiler pressure in the low-pressure cylinders. As the speed of the locomotive increases with the regulator valves in this position, the pressure in the steam chest decreases, owing to the small diameter of the auxiliary steam pipe, and the stresses on the parts then decrease. Experience shows that the working parts do not suffer in any way from this high pressure, for it is only momentary. With the regulator in the starting position, the locomotive, being short of steam, can only travel slowly. On further movement of the main regulator, the small port admitting steam to the low-pressure steam chest direct is closed, and the large ports in the main valve admit a full bore of steam to the high-pressure cylinder. Four-cylinder balanced compounds can be built on this system also.

To enable the regulator valves to be easily worked, the jockey valve and main valves are actuated by separate links. With this arrangement the jockey valve opens first, and on closing the regulator shuts last, thus always balancing the large valve. Owing to the position of the cranks actuating the links, the leverage on the main valve is also greatest when the pressure on the face is greatest. Even with large valves and high pressures this design of regulator is easily moved by hand. With this

form of compound no special instructions are required by the driver. The locomotive is manipulated exactly as is a simple engine, and it never fails to start easily, even with very heavy trains on severe gradients.

The results of the fuel tests I am about to give were obtained with a number of the 1000 class compounds as compared with the 700 class simple engines. Both classes have Belpaire boilers. The leading particulars are as in Table I. The first five compounds carry 200 lb. The higher pressure put in the later engines was to give a reserve of steam on heavy banks, rather than to secure increased economy in fuel.

Table I.

Type of engine.	Pressure per sq. in.	Grate area, sq. ft.	Total heating surface sq. ft.	Wheels.	Cylinders, dia.
Compounds..	220	28·4	1473	7ft. 0in.	(1) H.P. 19in. × 26in. (2) L.P. 21in. × 26in.
Simple ...	180	25	1528	6ft. 9in.	19½in. × 26in.

It will be noticed that the compounds have slightly less heating surface but larger grate areas than the simple engines. More heating surface would have resulted in greater economy in fuel; but the main object was to produce a locomotive of moderate weight with a maximum hauling capacity on gradients of 1 in 100, and capable of running at high speeds. That this result has been obtained is apparent, when it is stated that the allowed load in any weather for the 700 class engine on limited expresses is 180 tons, whilst for the compound it is 210 tons. This greater capacity for hauling heavy loads is partly due to the extra grate area and partly to the nature of the draught produced by the blast pipe of the compound engine, for more steam can be obtained from a given boiler on a compound engine than can be obtained from it on a simple engine. Indeed, drivers of compounds will, if not checked, take such heavy loads without an assisting engine that the fire-boxes are apt to suffer unduly. With regard to the question of the mileage obtained with the compounds and simples during similar intervals, including those at work and under repair, the compounds give over 20 per cent. better results than the simples.

To sum up as regards traffic working, the compounds take heavier loads, work a greater mileage, and have less frequently to be assisted than the simple engines. They are, however, more expensive to build and repair than the simple engine, but are more economical in fuel.

The coal consumption results here given were for trips made by engines as worked by drivers in ordinary running, no inspectors or others being on the foot-plates. The period chosen for making these tests was when trains were comparatively light, and no assisted trains have been taken into account. When the heavy summer traffic is being worked, the simple engines are largely assisted, and a proper comparison on a wide basis is not then possible. The following table gives the result of these workings:—

Table II.

Type of engine.	Average weight of train.	Train miles.	Gross ton-miles.	Lbs. coal per mile.	Lbs. coal per ton-mile.
Compounds ...	289	16,599	4,802,248	37·5	·129
Simples	281	10,582	2,975,668	39·2	·139

It will be seen that the compound engines took rather heavier loads than the simple engines, and on the ton-mile basis the economy of the compound as regards coal is 7¾ per cent. better than the simple. To this must be added the saving resulting from the much less double heading required. The greater duty which can be obtained by the compound, as regards weight of train hauled, is due to the fact that the blast pipe orifice can be made small enough to give a fierce draught without checking the engine as regards speed. With a larger blast pipe orifice I have found that they will work the lighter trains even more economically. Some of them are now fitted with a variable blast pipe, and much better all-round results have been obtained, as regards fuel consumption, with its assistance; 7¾ per cent. may not seem a large saving to effect, but when the great cost of coal to a railway company is considered, it is really a very considerable economy to secure in addition to obtaining a light engine of great hauling power.

The coal burned is that consumed by the engine in lighting up, shunting, working to and from the train, and standing during intervals between workings. Tests with two engines, both in very good condition, give an economy in favour of the compound of about 14 per cent. The difference between individual tests and the all-round results is due, I think, partly to the fact that the high-pressure engines lose more water through tube and stay leakage, on the average, than do the lighter pressed simple engines. And again, drivers of powerful engines keep time better up the banks, and do not run so fast on down grades and on the flat. For test runs, also, there is no shunting, &c., and the saving during running is a percentage of a smaller total coal consumption.

I have no hesitation in saying that the compound engine does better work than the simple engine from the point of view of working traffic, and that the economy in fuel obtained more than pays for the additional cost. By increasing the heating surface of the boiler and, therefore, the weight of the engine, greater economy of fuel could have been obtained, but such a plan was not admissible.

SOME RECOLLECTIONS OF SOHO FOUNDRY, ITS MEN AND METHODS.

By CHARLES H. WALL, M.I. Mech. E.

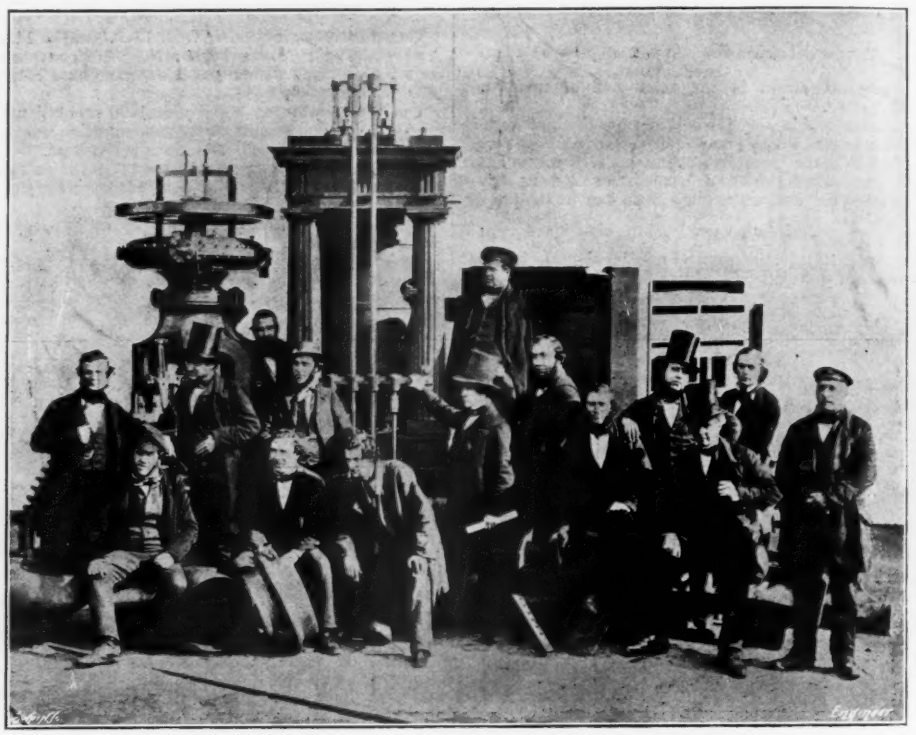
There is often some misunderstanding as to Soho Foundry and Soho Works. Soho Foundry was the engineering works founded and carried on by Mathew Boulton and James Watt. Soho Works was the large factory originated by Mathew Boulton in connection with his own private business, with which Watt had no connection. These notes refer to Soho Foundry.

The early photographic portrait group—Fig. 1—was taken about 1860 to 1862, some years before I was engaged there. The names of the worthies who appear in it are given beneath it. Mr. Brown was at that time managing director, and was known as a thoroughly good business man. He left Soho about 1873 or 1874. At that time a Mr. Hamilton was general manager. He invented the side pockets used in Lancashire boiler flues. He was followed by a Mr. Sanders, who invented a railway brake, which was tried by the Midland Railway at Derby, the first being made at Soho. He was known among the men by the title of "the Shah," on account, I suppose, of that potentate's visit to this country about that time. Mr. Darlington then succeeded as manager, having previously held the position of cashier, and he held the general managership till the closing of the works.

Mr. Carmichael, works manager, came to Soho from Portsmouth Dockyard in 1850. To him was deputed the duty of taking down and re-erecting at South Kensington Museum, Watt's "Lap engine" from Soho Works. This

An interesting feature in connection with this photograph is that each man's department can be recognised by his having something in his hand representing his work, or from his standing by a piece of work for which he has been responsible. Thus Mr. Carmichael holds a two-foot rule; Mr. Garland a roll of drawings; Walton, the coppersmith ("Old Copper"), holds the well-known expansion joint; Hardy, the boilermakers' foreman, is behind a tube plate; Lewis, the pattern foreman, is by a toothed wheel; and Shaw, the foundry foreman is in front of a bed-plate. The face between the coining press and the cylinder nozzle I am not able to identify. Of the possessors of the fourteen names given, all but two have joined the majority. They are Lewis, who I believe is still in London, and Mr. Anderson, who is living at Handsworth, and to whom I am indebted for the names of those in the photograph, having compared it with a group he has which was taken at about the same time, but with one or two more officials in it. With several of them I was acquainted when I first went to Soho.

Through the kindness of Mr. W. H. Dugard, M.I. Mech. E., I am enabled to add several photographs which I believe you have not published before. One—Fig. 1—is interesting as illustrating the Boulton coining press in the mint at Soho Foundry. About the year 1860 an order was received at Soho Foundry for twelve of these presses for the Calcutta Mint. A Mr. Harvey, engineer to the Calcutta Mint, conceived the idea of driving them by means of compressed air in a cylinder which was a segment of a circle, the piston of which was attached to the end of a radial arm which rotated the screw of the press. This press is illustrated in the group—Fig. 1.



Mr. CARMICHAEL, *Works Manager.*
Mr. FRANK SHAW, *Foreman Foundryman.*
Mr. DAVID ANDERSON, *Second Assistant Works Manager.*
Mr. MICKLEJOHN, *Shipping Clerk.* Mr. HAZELDENE, *Assistant Office Manager.*
Mr. LEWIS, *Foreman Patternmaker.*
Mr. GARLAND, *Chief Draughtsman.*
Mr JOLLY, *Assistant Draughtsman.*
Mr. WALTON, *Foreman Coppersmith.*
Mr. HARDY, *Foreman Boilermaker.*
Mr. WILLIAMS, *Gate-keeper.*
Mr. FORBES, *Third Assistant Works Manager.*
Mr. BROWN, *Managing Partner.*
Mr. MOLLINEUX, *Foreman Blacksmith.*

Fig. 1—STAFF OF THE SOHO WORKS IN 1860

old beam engine was the first rotative engine ever put to work a factory. Of Mr. Carmichael's abilities as a mechanic I shall have to speak again when referring to special machines. He left Soho Foundry about the year 1863 to join Mr. Barrows, of Banbury, at Cherwell Works, afterwards Barrows and Stewarts. (Mr. Barrows married a grand-daughter of William Murdock.) Mr. Carmichael died in 1868. The manager before him was Mr. Buckle, who left Soho in 1850, to take the position of bullion master at the Royal Mint.

Mr. David Anderson also came to Soho from Portsmouth Dockyard about 1854. At first Mr. Carmichael's assistant, he succeeded him as works manager, and held the position till his retirement in 1883. It was under Mr. Anderson that I made my own first acquaintance with Soho Foundry.

Mr. Forbes was another assistant of Mr. Carmichael's, and became chief of the out-door staff, and was principally engaged in the erection of mints and engine and machinery abroad. He retired before Soho Foundry was finally closed, and died a few months ago.

Mr. Garland was chief draughtsman, and was responsible for the designing and estimating department. He left in the early seventies.

With regard to the other names, Mr. Hazledene afterwards went to the London office, and I believe he was in charge there at the time the foundry closed in 1894. All these foremen were sound practical men who understood their business; and at that time a large amount of freedom and responsibility in matter of detail was given to the heads of departments. They always came to the works in top-hats, which no doubt demanded respect from the workmen.

Harvey paid Mr. Carmichael £50 to design the press in accordance with his idea. A Colonel Smith came to Soho to inspect it on behalf of the purchasers, but its manner of working was so spasmodic that he condemned the lot, and James Watt and Co. were paid £500 each for altering the presses back to the old design. The presses shown in the photograph of the Soho Mint were of this original Boulton design. A trumpet-shaped rotating piece extended to the floor above the presses, its top part being parallel and free to rotate in a cast-iron bearing fixed to the floor. The bottom of this piece was formed with claws which dropped over a circular casting having fly-arms upon it, into which was fitted the screw of the press, the flange of the trumpet piece being further held down by bolts to this circular casting. Thus the circular casting and trumpet piece rotated, and rose and fell with the screw: The trumpet piece was hollow, and a lever was keyed to its upper end. This lever was worked by a vertical piston and cylinder of 20in. stroke placed outside the wall of the room in which the presses were situated, the piston and lever being connected by a bell-crank and rods. This motion performed the working stroke of the press. A loose connection was made by means of a rod passing through the hollow trumpet to a beam or lever poised on a centre, and having a rod connected to the piston of a second vertical vacuum cylinder placed by the side of the first. This second cylinder (of 12in. stroke) performed the duty of raising the screw and top die attached to it. The valve gear consisted of one valve only to each cylinder, actuated by the motion of the press. A constant vacuum was maintained in the cylinders on one side of the piston, the valves admitting air on the other side, or placing the pistons in equilibrium

HISTORICAL RELICS OF SOHO WORKS

Fig. 2—BOULTON'S COINING PRESSES

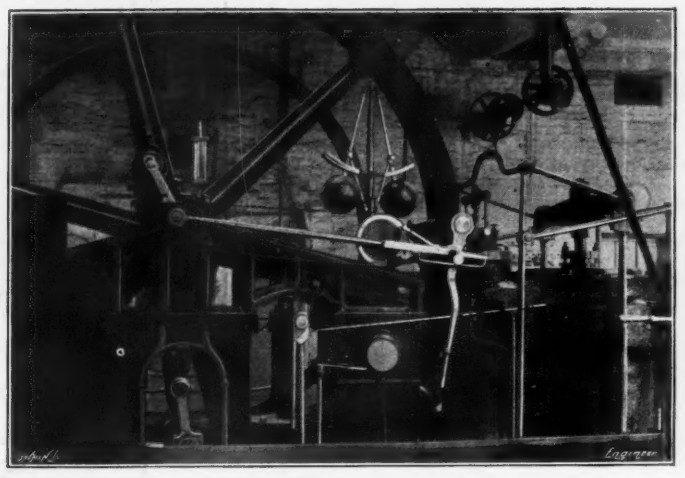


Fig. 3—SIDE LEVER ENGINES

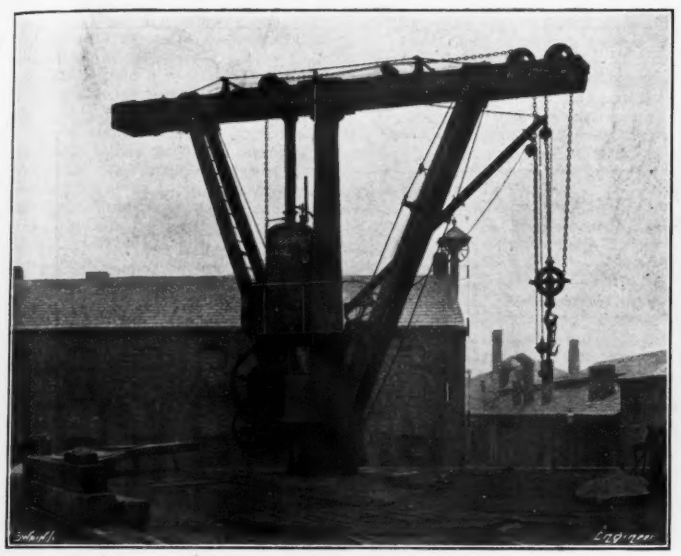


Fig. 4—MURDOCK'S 20-TON CRANE

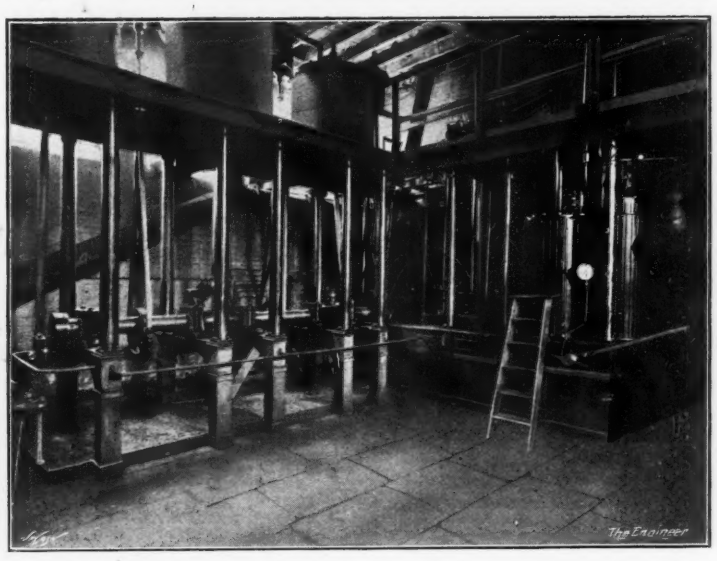


Fig. 5—MURDOCK'S BLOWING TUBS

as required. The presses struck 120 to 130 blows a minute. All that was needed to start them was to open the valve of the cylinder actuating the working stroke; after that the machine looked after itself. The horizontal cylinder, shown in the photograph attached to the press housing, contained a buffer spring fitted with a contact block of wood. This coming in contact with the fly arm checked the blow of the press and was adjustable. If the blow was too heavy the coin was damaged, if too light it was a waster. The shears and laying-on gear were worked automatically by means of a rod off the top lever. To the original workmen this method of driving these presses by vacuum appeared so mysterious that they named the vacuum tube the "Spirit pipe," and by this name it was always known. I should like here to state that three generations of men named Jerome worked in this mint from Watt's day to the eighties without a break.

MACHINE TOOLS AT SOHO FOUNDRY.

In respect to the tool illustrated in THE ENGINEER of September 10th last, and described as a boring machine, I would like to say that this was a tapping machine, and was principally used for tapping large nuts up to 6in. diameter. The long taps used can be seen in the illustration at the back. The boring of cylinders was performed in another machine described later. The lathe—Fig. 3, page 260—with a worm gear drive has a further interest in the fact that the worm wheel was a mortice wheel. This is the only case I remember of a worm wheel with wood teeth. The light planing machine—Fig. 7, page 261—had, besides the usual table, another with a rotary motion upon which piston rings were turned.

Slotting machine.—This machine, having a stroke adjustable up to 3ft. 6in., had a travelling head driven by bevel gear from the top, the stroke being regulated by tappets and a belt reversing gear. The cutting head travelling vertically, after the manner of a side-planer, and the frame carrying it, was fitted solidly to the wall. There was a circular table underneath with two feed motions, and a gap in the wall enabled wheels up to about 30ft. diameter to be machined. Next to this slotting machine was a boring machine, which was chiefly used for boring the gudgeon holes of engine beams. There was a radial drilling machine here which was also designed by Mr. Carmichael, and another was built later. All these machines were attached to the wall similarly to the slotter.

Boring machines.—At one end of the boring mill proper was erected a square high brick tower, some time in the sixties, the walls being built very thick for strength; attached to the walls inside were cast iron plates fitted with angle plates and adjustable screw dogs; these were fixed up the wall sufficiently high to set up the longest cylinder ever made at Soho (the largest I saw bored under this mill was 108in. diameter by 12ft. stroke, which, if my memory served me right, was for Vauxhall Waterworks, London), in the top of the tower a crane was fixed for unloading the cylinders off the wagon which brought them by rail from the foundry. The crane also withdrew the boring bar, the foundation plate at the bottom being fitted with the boring bar step in the centre,

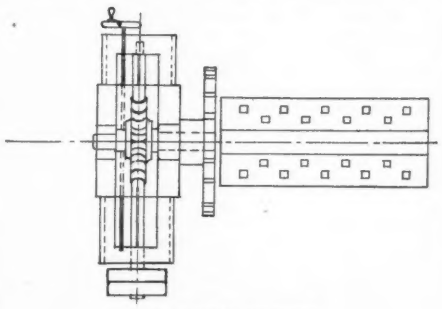


Fig. 6—FACING MACHINE

this bottom plate was fitted with cramping bolts to set and fix the cylinder central to the bar. The bar was driven vertically from the bottom by gearing, and was held in position by a cross bar at the top. The cylinders were bored by a disc fitted with a number of tools, feed motion being supplied by a screw star driven from the top, the screw lying in a groove longitudinally to the bar running through a metal nut fixed to the disc, which was made a working fit, and also was the means of driving the disc. The other boring machines, of which there were several, were all horizontal, and driven practically the same way as the vertical one, most of them in the original form in which Watt left them, except for an alteration here and there to the method of driving them. There were the remains of an old sofa in this mill, on which it was said James Watt often sat when discussing matters over with the workmen; the floor of the mill was laid in white stone slabs, and in Watt's time was kept in trim order.

The facing machine—Fig. 6—known among the workmen as "the devil," was a machine used for machining the ends of large flange pipes, the main bed was long and somewhat narrow, fitted with V blocks to carry the pipes. At the end, at right angles, was the facing tool; this was a disc fitted with a number of tools in grades from roughing to finishing. It was driven by belt with a fast and loose pulley on the end of a shaft at right angles, carrying a worm in a frame which was free to move through the worm sliding on a feather on the shaft. This frame carried a worm wheel attached to a shaft in two bearings, on the one end of which was fixed the disc with the cutting tools. This frame worked on slides, the feed being actuated through a star and screw, somewhat similar to the slide rest of an old-fashioned lathe. This end casting was rectangular in shape, and, of course, stood at right angles to the bed; other work besides facing pipes was accomplished. Mr. Carmichael designed this machine in the fifties; the work was carried out by Mr. Harper, his assistant. The chief points embodied in this machine have of recent years been brought out as new.

Magneto cleaning machine.—This was used for cleaning the brass and copper borings. The machine consisted of a shaft fitted with permanent horseshoe magnets in the shape of a screw which worked inside a rectangular box driven by belt power. At one end was a hopper into which the borings were fed, the action being that the screw carried the material along and delivered it at the other end; the iron was collected from the magnets as they revolved by means of brushes. This machine was made at Soho somewhere about 1850.

Slot drilling machine.—This was another example of the genius of Soho. It was used for drilling cottar holes in piston rods, connecting rods, and all other places where cottars were required. The operation consisted in the drills starting together at the opposite sides; they were fed automatically, one being thrown out in advance of the other, which was run until the hole was finished, this action being necessary to avoid the drills coming in contact with each other. This machine started somewhere about the sixties.

Wall planing machine.—This was another example of Mr. Carmichael's mechanical engineering. He designed this machine in the early fifties, the work being carried

out by Mr. Harper, his assistant, and it worked right to the end of Soho foundry's career in 1894. The framing for carrying the tool box was fixed to the side of the wall. The tool box being driven by a screw with fast and loose and reversing pulleys on the end; this tool box had also a vertical movement, the whole of the box working on square slides with the screw in the centre horizontally. There were very large tables bolted to foundations in the floor with the usual fixing holes of T slot type into which the bolts were inserted to hold down the work by means of straps, &c. This machine was used chiefly for planing fly-wheel sections, marine engine standards, cylinder bases, &c. The tool box was double-acting, swivelling on a pin so as to bring the two tools into position automatically. The action of the machine was as follows:—When taking a cut, the main screw carried the slide with the tool box along the face of the work, arriving at the end of the stroke the machine was reversed by means of a long rod running parallel with the main screw, attached to which were tappets, which could be altered to suit the stroke. These came in contact with a tappet fixed on the work, the result being that the belt was shifted over by a lever which had a weight on it. The moment the lever passed the vertical centre the weight fell over against a stop, thus reversing the motion. The return stroke being completed, the tappets came in contact again, thus reversing again for the next cut. The vertical feed to the tool was obtained by a star-feed motion from the bottom in contact with a tappet. This machine had at full stroke a travel of 15ft. Another machine of similar type with about 25ft. stroke was built later. There was another planing machine, screw driven, with a reversing tool box for cutting both ways. This was a very old one, probably built by Whitworth.

Blowing tubs (Fig. 5).—These were designed by William Murdock and erected by him; you will notice there are three tubs driven by a beam engine in series, each tub being driven by its own crank shaft, the shafts being connected together by means of drag link, the valves were worked by excentrics and rods mechanically. The collecting pipes originally conveyed the air to a large rectangular tank under the ground level in the boiler shop, this formed a reservoir on which was a safety valve loaded to the required pressure. From this tank each hearth in the boiler shop and smiths' shop adjoining was supplied with blast. Mr. Carmichael during his time had this reservoir shut off, the hearths were then supplied direct. This engine and tubs worked right up to the close of the works in 1895.

Fig. 4 is from a photograph of 20-ton hand crane with auxiliary side crane for light weights. This crane was another of Murdock's designs, the framing originally, including the centre post, being all of oak. Somewhere in the late seventies the management at Soho thinking the centre post was decayed and unsafe, instructed Mr. Harris, the foreman patternmaker, to cut it out; after doing so it was found the oak was practically as sound as the day it was put in by Murdock; the present centre pillar was then constructed in wrought iron boiler plating as shown, the crane continuing its usefulness as before. The boiler and engine were added for steam power somewhere about 1880 90. The building immediately behind the crane with the workmen's time bell on the end was called the "Magazine." It was here that all the detail parts were packed and got ready for despatch. The building to the right was the smiths' shop, at the far end of which was the boiler shop; whilst at the end nearest to the crane was the office of the general manager, the last to occupy this being Mr. Darlington, who has recently died. The main entrance to the works was between this office and the gate-keeper's time office, through which passed all the foremen, and a little further away the workmen passed through at the other end, the intermediate space being occupied by the general offices, whilst over the top was the drawing-offices. To the left of the magazine is the high square tower of the boring mill.

Fig. 3 is from a photograph of a side lever marine engine of Napier's type, but made by James Watt and Co. This engine was used for driving what was called the 14 horse-power shop, with its lathes and planing machines, &c. The framing of this engine was malleable iron. The parallel motion was added during my connection with Soho, being carried out by a Mr. Judge. The engine had for probably forty or fifty years, or more, previously to this, worked without it, and so far as I could see worked equally as well. The old D slide of this engine had a balance weight attached to a lever for balancing the weight of the valve. This was taken off about 1875, a circular valve and muzzle of the Rooke type being substituted. This valve was balanced by the steam being admitted to the centre, the top portion being larger in diameter than the bottom, the steam acting on this difference of area compensating the weight of the valve.

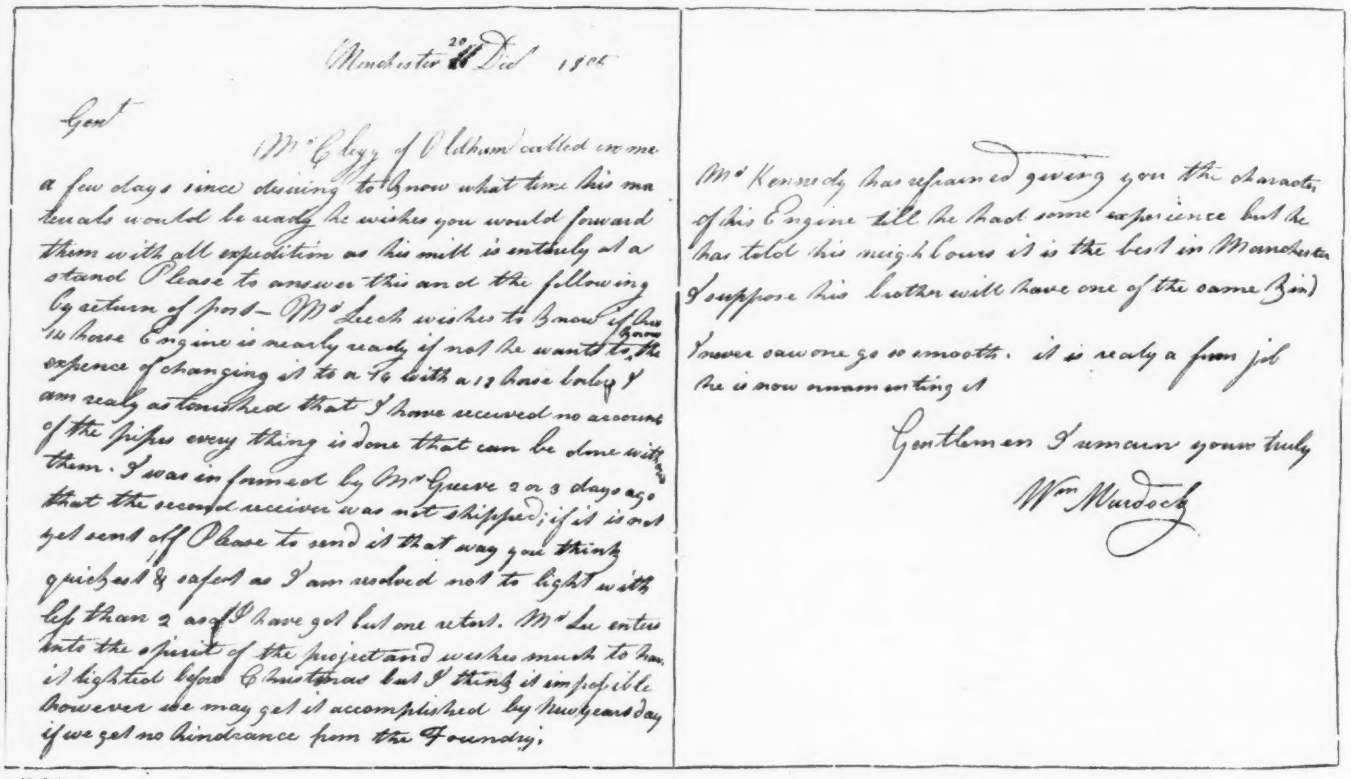
SOHO METHODS.

A few notes on the methods adopted at Soho Foundry in the construction and erection of engines, &c., may be interesting. The machining, fitting, and erecting shops were known as the boring mill, the 6 horse-power shop, the 14 horse-power, and the big shop where the engines and machines were finally assembled and erected. Castings, such as cylinders, pump barrels, &c., were delivered from the foundry first to the boring mill, where they were bored to the sizes given on the drawings. All the small castings and forgings were distributed chiefly to the bottom machines bay of the 14 horse-power shop. Various lathes, planing, slotting, and other machines, after being turned, &c., were handed over to fitters in the other bay of the shop, a bench going the whole length on the one side, where they were finished ready for erection. In addition to this work small rock boring machines and coining presses were erected here. All pistons and rings were here fitted up. The top portion of this shop had some heavy planing machines, lathes, and radial drilling machines, with deep pits below them to enable large pieces to be dealt with. These were used for some of the heavier work. There was also a vice bench on one side of this bay where all boiler taps, brass cocks, indicator cocks, and brass work were finished. This shop was driven by the side lever engine, illustrated, which was situated in the centre of the shop which was L shaped.

The 6 horse-power shop contained two or three big lathes and the large nut tapping machines—illustrated in your issue of September 10th—these were in one bay, the shape of this shop being like the letter T. The top end portion, to the right, was occupied by hand lathes and small nut tapping and facing machines. It was here that all the Soho apprentices had their first practical lesson in engineering. They were taught to use the hand turning tool, and some of the hand work done on those lathes would shame a more modern lathe man. As the boys progressed they were moved on to the other departments. Cylinder studs, bright nuts and washers, and all kinds of lever handles were the production of this part of the shop. The foreman over the boys in my time was named Stokes, and a lively time he often had with them. He was an ingenious workman; the brass screwed ferrules made in his shop, and used for screwing down the tapes on the ends of the surface condenser tubes, were plain, with a slot across one end into which a T spanner fitted for screwing them tight home. The tubes often worked through out of position, especially as the tapes deteriorated. Stokes conceived the idea of cutting these slots on the angle, the deepest side being on the outside. The high side was forced inwards by a flat surface tool; this formed a projection to the inside diameter, which made it impossible for the tube to work out of its place. At this time the other part of the shop was used for erecting pump barrels and small engines by a man named Thompson, who used to come in a tall hat and worked in a white apron, as also did a man named Tranter. These were both old men, and the two last workmen who ever came to Soho thus attired.

The big shop.—This shop was somewhere about 300ft. long by 60ft. to 70ft. wide. It had three overhead hand-power travellers, two of 20 tons, the other about 10 tons. There were also jib cranes fixed to the side walls for the use of fitters when erecting small work. At one end of this shop was a very large and powerful lathe with thirty-six different speeds; it would swing anything up to 45ft. in diameter. I have seen 35ft. fly-wheels weighing as many and more tons turned on the rim by this lathe.

The wall planing machines referred to previously were fixed on one side of this shop, whilst on the other was the powerful slotting machine and radial drilling machine also mentioned before. This machine had head room of 14ft. to 16ft. above ground level, in addition to a pit; the machine known as the "devil" worked up at the other end on the same side of the shop. For large fly-wheels requiring boring only, provision was made in the centre of this shop with foundation carrying a centre for the boring bar. The wheels were levelled up on plates true to this centre, a portable boring machine being fixed over the top, and bored in the usual way, the machine being driven by



Manchester 20th Dec 1804

Genl

Mr Clegg of Oldham called on me a few days since desiring to know what time his materials would be ready he wishes you would forward them with all expedition as his mill is entirely at a stand Please to answer this and the following by return of post— Mr Lee wishes to know if the 10 horse Engine is nearly ready if not he wants to the expence of changing it to a 16 with a 18 base baby & am ready as finished that I have received no account of the pipes every thing is done that can be done with them. I was informed by Mr Greave 2 or 3 days ago that the second receiver was not shipped; if it is not yet sent off Please to send it that way you think quickest & safest as I am ordered not to light with less than 2 as I have got but one steam. Mr Lee enters into the spirit of the project and wishes much to have it lighted before Christmas but I think it impossible however he may get it accomplished by New years day if we get no hindrance from the Foundry;

Mr Kennedy has refrained giving you the character of his Engine till he had some experience but he has told his neighbours it is the best in Manchester I suppose his brother will have one of the same Kind

I never saw one go so smooth. it is really a fine job he is now manufacturing it

Gentlemen I remain your truly

Wm Murdock

The Engineer

Fig. 7—AUTOGRAPH LETTER BY WILLIAM MURDOCK

belt from the shafting. This same centre was used for large spur wheels which had machine-cut teeth, a milling machine being fixed and driven for this purpose in a similar manner. Wheels up to 60ft. diameter were cut here. Deep square pits existed in the floor, and were covered over by planks when not required. They were used for the erection of vertical standard engines. A large marking-off plate was used; this had a jib crane with rack on the jib for moving the load in or out radially.

At one corner of the big shop was a gauge and tap stores connected by a door with a counter. A little old man named Simms was in charge. There were frames on the wall, triangular in shape, fitted with racks carrying finely tempered steel bars about $\frac{3}{8}$in. to $\frac{1}{4}$in. square, with centre punch points in lengths from 3in. up to 6ft., rising by $\frac{1}{4}$in. up to 3ft., afterwards by $\frac{1}{2}$in. and $\frac{1}{4}$in. These were used as standard lengths, as no man was allowed at Soho to measure lengths when working to a drawing with his rule. As an illustration, suppose a man had a beam to mark off, his drawing would give length from centre gudgeon to connecting-rod gudgeon centre so much, centres between parallel links, and so on. He applied at the gauge stores for these lengths. Simms had a long steel bar fitted on the bench with one head fixed, the other being a sliding head held by a screw, another screw giving a micrometer adjustment. He took the steel gauge or gauges of suitable length to make up the length required, set the sliding head to them, then adjusted his milling screw to suit, took a bar of iron—and according to length so was the strength from a $\frac{1}{4}$in. square up to $\frac{3}{4}$in. square or more—the ends of which were bevelled and filed flat until they passed the gauges with a touch, the length previously being stamped on them. Iron centres were driven in the rough holes cast in the beam, the centre of the main gudgeon marked, the length gauges laid on, and

the centre of the other holes marked from the gauge. The gauges were afterwards returned to the stores, and, if necessary, filed away for future reference.

An erector going out to erect a pumping engine had all his centres supplied to him with gauges of this type, and, if very long ones, these were made in two or three lengths properly marked to come together for the particular length they represented. All radius curves on bearings and necks of shafts were turned to gauge supplied from the stores.

Main crank shaft bearing brasses were all turned short to the length of neck on the crank shaft; this varied $\frac{1}{32}$in.-$\frac{1}{16}$in. up to $\frac{1}{8}$in. in larger shafts. There were the usual male and female ring gauges for turners to work to; and limit gauges to be used with regard to shrinking of cranks on to the shafts. The method used was a simple and clean one. In shrinking a crank on to a shaft, the shaft was levelled up near to an iron bath containing lead, under which was a fire, the crank was adjusted in a crane to see that the keyway was in line and the crank level; the latter was immersed in the lead bath, and, as soon as the limit gauge passed, the crank was taken by the crane and pushed over the shaft end, a temporary gauge key inserted, and the whole left to cool down.

In marking holes off for drilling on the various parts of work thin zinc sheets were used with the pitch and size of the holes cut through; these were carefully marked as to which side of templet came next to the casting. I never knew a failure of work coming together from this system, as it was all worked from either the vertical or horizontal centre lines. All bearing brasses were cast with a clearance on the sides, the actual contact surface for the shaft to rest on being 120 deg.; this clearance extended longitudinally to each end of bearing within, say, 1in. to 2in., according to size. The object was to have a cool running bearing. Another feature of the Soho plummer blocks was they were all bored circular, the bottom brass could be twisted out of its bearing by just easing up the weight, the top bearing having a rectangular snug on it over which the gland cap fitted, the brasses butting together at the centre, it was impossible for them to move when screwed down.

In the construction of engine beams the two flitches were first bolted together through the distance pieces, the beam then erected upright or "work-ways" on wood packing, that they might obtain their normal condition. In this position straight edges and lines were fixed from which levelling points were marked horizontally and vertically by chipping a square about 1in. or so to suit small cube steel levelling pieces, which were 1in., $\frac{3}{4}$in., and $\frac{1}{2}$in. on the sides; this done the beam was turned on to its side, levelled up, the gudgeon centres and size of holes marked off. The beam was then removed on to a long bed-plate levelled up to the points marked as above, and properly secured, the holes were bored one after the other by being moved along on the bed-plate; this boring machine being specially designed and made at Soho for the purpose; the holes were thus all parallel to each other.

In writing these notes I am indebted for assistance, which has readily been given me by some of the old workmen still living, and with whom I was associated during my time at Soho, viz.:—Mr. David Anderson, works manager; Mr. Thomas Jerome, who had charge of the Mint, as did his father and grandfather before him, his grandfather having worked in the original Mint of James Watt as already mentioned; Abel Hall, Arthur Bradley, erectors in the big shop; T. Wheeler, Tom Beasley and W. Hackett, all planing machine hands; and Edward Jones a lathe hand. These men all bear names connected with Soho for many years, their fathers having worked there before them.

Some controversy having taken place as to the correct spelling of William Murdock's name, we are enabled to give herewith a facsimile reproduction of a letter sent by him from Manchester to Boulton and Watt, at Soho, Birmingham, and dated December 20th, 1805. For the loan of this letter we are indebted to the courtesy of Mr. R. H. Kirton, of the Cornwall Works (Tangyes, Limited), Birmingham. It will be observed that this letter definitely sets at rest the question of whether the name should end in an "h" or a "k." An examination of it will show a final "h" in the name "Leech," in the sixth line of the first page, and a final "k" in the word "think," at the end of the thirteenth line. A comparison with these two letters with the final letter of the signature leaves no room for doubt that the latter is a "k," and that the correct spelling of the name is "Murdock," and not "Murdoch," as some people have urged.

LITERATURE.

Recent Cotton Mill Construction and Engineering. Third Edition. By the late Joseph Nasmith and Frank Nasmith. Manchester: John Heywood, Limited. Price 6s.

THE first edition of this book was in great part a reproduction of an article which appeared in the *Textile Recorder* for May, 1894. As no other publication dealing with the subject in the same way exists it is not surprising that the sale has already exhausted two editions. The third edition has been largely re-written, and new chapters have been added, so that the book may be regarded as an up-to-date standard work on a subject which has seen considerable developments in recent years. Practically every phase of cotton mill engineering is dealt with, separate chapters on constructional details, fireproof construction, reinforced concrete, fire-extinguishing appliances, lighting, heating, power plants, gearing, rope and belt driving, &c., being included. The sections of the book dealing with construction will be found particularly useful to architects and others in designing factories and workshops according to the best modern methods, and those who are still unconvinced of the suitability of reinforced concrete for this class of buildings will find information concerning its application to mill buildings on the Continent and in the United States, which show how far removed this method is from the experimental stage. With regard to cost the authors state that small buildings of reinforced concrete show very little saving over the older types, but as the amount of structural work increases so does the comparative cost of reinforced work decrease, other considerations being equal. In modern cotton mill design one of the most conspicuous features is the large window area aimed at. In this respect ferro-concrete appears to possess advantages hitherto unattainable.

The chapter on heating, ventilating, and humidity, is of special interest at the present time on account of the official steps which are being taken to remedy the condition of the workers in the steaming sheds. The various systems of humidifying the air are all described, and the reader will be able to obtain some idea of the difficulties which have to be overcome in obtaining the necessary uniformity of humidity to give good results under varying climatic conditions. There are two distinct methods of humidifying the air supplied to mills; namely, first, the production of a spray by the action of a jet of air or water under pressure against an emerging stream of water; and, secondly, the charging of the air with moisture prior to injecting it into the room. In this section, on page 117, the editor has allowed an obvious error to escape his notice with regard to temperatures and pressures of steam used. The chapter on steam boilers contains much useful information collated from reliable sources. The chapter on steam engines comprises descriptions and illustrations of the most approved forms of engine now in use. Electric driving is treated at some length in Chapter XVII., and after quoting tables on the subject by reliable authorities, the author comes to the conclusion "that there is not any considerable advantage to be gained at the present time from electricity as a motive power for mills." The chapter on gas and oil engines is chiefly devoted to descriptions of the Körting gas engine which has been adopted to drive a mill at Stalybridge, and of the Diesel oil engine. The latter is illustrated driving a cotton mill in Bombay, and is capable of developing 400 brake horsepower. Other sections of the book deal with gearing, rope and belt driving. The illustrations, with a few exceptions, are satisfactory, but the format of the page is rather too small to admit of clearness of detail in some cases.

Drapers' Company Research Memoirs: On a Practical Theory of Elliptic and Pseudo-elliptic Arches, with special reference to the Ideal Masonry Arch. By Karl Pearson, F.R.S., W. D. Reynolds, B.Sc., and W. F. Stanton, B.Sc. London: Dulau and Co.

THE theoretical treatment of masonry arches being based largely on assumptions has hitherto been admittedly defective. In the present treatise, which forms No VI. of the Technical Series issued by the Department of Applied Mathematics of University College, London, the authors have made a serious attempt to place the theory on a sound scientific basis, and to clear up several of the obscurities associated with it.

The treatment given to the subject by the authors is, of course, essentially mathematical, and without reproducing a large proportion of the algebraical work it would be impossible for us to describe in a satisfactory fashion the various considerations dealt with. We can, however, briefly indicate some of the more important results arrived at, leaving the reader to the original work as far as the method of arriving at them is concerned.

Under ideal conditions the centre line of a masonry arch rib, designed for a particular span, rise, and system of loading, should coincide with the line of resultant pressure between the voussoirs. Taking this as a guide, it is well known that an arch should be made in the form of a parabola or of a catenary, according as the loading is distributed uniformly over the horizontal span or over the rib itself. It is less well known, perhaps, that in cases where the arch has to support vertical loads extending uniformly from the rib to a horizontal level coincident with the directrix, the catenary is again the correct curve to employ, and of this statement a proof will be found in the book. The catenary is a difficult curve to construct, and hitherto in practice the parabola has been substituted for it in a large majority of the cases where theory demands its use. On this point the authors of the present work have something to say. General expressions for the catenary, parabola, circle, and ellipse, with reference to the end of the vertical diameter as origin, are obtained, and are shown in the form of explicit equations of y in terms of x. Taking the parameter in the case of the catenary as c, that of the parabola as $2c$, the radius of the circle as c, and the semi-axes of the ellipse as $\sqrt{3}c$ and $3c$, it is shown that the ellipse affords the nearest approximation to the catenary. In a particular case which the authors work out, where the ratio of rise to span is $\frac{1}{5}$, it is shown that on most drawings of arches the discrepancies involved by the substitution are within the limits of draughtsmanship. From these considerations it is concluded that for the fairly flat arches of modern practice designed to carry a uniform load per foot run of the rib, or per foot of vertical height from the rib to a certain definite level above the central line at the crown, the elliptic arch is the proper form to employ. The usual substitution of the parabola for the catenary is not justified, we are informed, unless the ratio of rise to span is less than $\frac{1}{10}$.

It will be at once seen that the vertical loading of the elliptic arch is fixed by a certain definite height. Taking the span as l and the rise as r, this height is given by $c = l^2/8r + \frac{1}{6}r$. But the authors point out that there are many cases in which the actual rise given to the arch is of little account, so that c and l being settled *a priori* we may choose r to suit the above relation. An interesting example of a problem of this class is worked out and illustrated in the treatise.

The writers next consider the case of an arch loaded with a uniform rib load—or the equivalent vertical load—and a uniformly distributed platform load. A curve half way between the catenary and the parabola is the natural result, although the equations to it and the integration involved in arriving at them are complicated. To this curve the authors give the name "compound catenary," and proceeding to analyse it, and comparing it with the equation to the ellipse, show that this curve is even better approximated to by an ellipse than is the simple catenary. Thus the elliptic arch is again the ideal form, when the loading consists of a uniform rib and platform load. An example of the fundamental work in connection with the design of an arch of this class is gone through and illustrated.

The majority of arches cannot, however, be placed under one or other of the above classes. In addition to the rib, vertical, and platform loadings of the foregoing arches, we have also to consider the weight due to the backing and the ballast. To investigate the ideal form for an arch of this type the backing is given a form expressible algebraically, and the authors have provided an equation which, by a suitable choice of constants, can be made to suit a variety of commonly-adopted shapes.

After much laborious work, the resultant equation to the ideal form for the arch is obtained, and is shown to be of the form $y = ax^2 + bx^4 + cx^6 + \&c.$ From the investigation and results of the previous cases it might be surmised that an equivalent elliptic arch could be found for this case also. When a comparison, however, is made between the above equation and that of the ellipse expressed in a similar form, it is seen that this is not so, and the authors show algebraically and graphically that an elliptic arch can be substituted justifiably for the ideal form only in those cases where the ratio of rise to span is very small—smaller, in fact, than is met with in practice.

If we assume that the above equation is convergent, a point apparently tacitly assumed by the writers, then we can obtain an approximation to the ideal form for any arch by using as many of its terms as we like. Thus, regarding x^6 and higher powers of x as negligible, it is fairly easy to plot the curve under any given conditions of loading. The determination of the constants involved is a trifle laborious, and in the case of the two-term equation, a cubic equation has to be solved. To secure a higher approximation, the third term is included, and to determine the constants in this case a quintic equation must be solved. In both cases the authors employ Newton's method for the solution of the equations, and they have plotted the resultant curves. An inspection of these, and in particular of the last, shows that the centre line of the arch so determined and the true line of pressure agree very closely. The curves of these arches found, as explained above, from the equations given, and by retaining or neglecting the sixth term is, of course, neither an ellipse, catenary or parabola, and to it the authors have applied the name "pseudo ellipse."

The methods of design indicated in the book are novel, and are clearly in the direction of an advance upon the present haphazard style, which, after all, depends not on the actual stresses in the arch, but on those which would be called into play just as the arch was on the point of collapse. Graphical methods are, however, always sought after wherever possible, and we doubt if designers will be readily induced to undertake the mathematical work involved in this treatment of the subject. At the same time some valuable information could be gained by the designer if the new method were compared as to its results with the old, and if only as a check on the latter, it would repay any time given to mastering it.

Annuaire pour l'an 1910. Publié par le Bureau des Longitudes. Avec des Notices Scientifiques. Prix net, 1f. 50c.

(By the Late PROF. BAUERMAN.*)*

WITH the advent of the New Year this well-known Annual appears in its accustomed form for the ensuing year. Following the arrangements adopted at the beginning of the century, the notices, apart from the main astronomical series, are confined to physical, chemical, and similar data, the geographical, statistical, actuarial, and similar matters being reserved for the alternate years. The supplemental notices include an account of the International Committee for the execution of the Photographic Map of the Heavens, held in Paris under the presidentship of M. Bailland, and an article on the tidal deformation and the elasticity of the earth's crust, in which this very complicated subject is treated in a somewhat popular manner by M. Sallemand. Of greater interest, however, from the bibliographical point of view, is the third supplement, which contains a complete classified list of the scientific notices that have appeared in the "Annuaire" since its first publication 115 years ago. This is further enhanced by an alphabetical index, so that all the famous papers may be easily identified.

BOOKS RECEIVED.

Cape Colony To-day. Second edition. Issued by the Cape Government Railway Department. Capetown: Townshend: Taylor and Snashall, printers.

Wireless Telegraphy and Wireless Telephony. By H. E. Kennelly. Second edition. London: T. Fisher Unwin, Adelphi-terrace, W.C. Price 4s. net.

The Guide to South Africa, 1909-10. By A. S. and G. G. Brown. Seventeenth edition. London: Sampson Low, Marston and Co., Limited. Price 2s. 6d.

The "Timber Trades Journal" List of Shipping Marks on Timber. 1909 edition. London: William Rider and Sons, 164, Aldersgate-street, E.C. Price 7s. 6d. net in cloth, 9s. net in leather.

Applied Mechanics, Vols. I., II., III., IV. Professor Jamieson. Seventh edition. London: Charles Griffin and Co., Limited, Exeter-street, Strand, W.C. Price, Vol. I., 6s.; II., III. and IV., 5s. each.

The Dynamo: Its Theory, Design and Manufacture. Two volumes. By C. C. Hawkins and F. Wallis. Fifth edition. London: Whittaker and Co., 2, White Hart-street, Paternoster-square, E.C. Price £1 1s. two volumes.

LOCOMOTIVE PROPORTIONS AND POWER.

By G. JAMES WELLS, Wh. Sc., Assoc. M. Inst. C.E., M.I. Mech. E.

No. I.

THERE is an immense amount of interest bestowed upon railway matters to-day, and possibly the locomotive obtains the largest share. This is not surprising, for it is the part that looms large in the eye of the travelling public, and with the technical man it is usually scanned most closely. According as the train arrives at its destination early or late so is the judgment passed upon its capacity as well as upon that of its designer. It is a very difficult thing to say offhand which type of locomotive is the better able to deal with the duty allotted to it, and the object of this discussion is to arrive at some basis upon which the matter may be examined and some idea of the power of the machine to do its work fairly arrived at.

The power of single-expansion engines—no matter for what purpose it is designed—is proportional to the volume swept out by the pistons in unit time. The greater this volume the greater will be the power that may be developed; thus the first factor to be assessed is the capacity of the cylinders provided. The size of the driving wheels must be allowed for, and this has been effected by calculating the volume swept out per mile without slipping.

The power developed will also in part depend upon the mean pressure maintained in the cylinders, and is a difficult matter to predict. Generally it depends upon the boiler pressure, cut-off, and speed at which the engine is running. With a fixed cut-off and steady boiler pressure the mean pressure falls as the speed increases; but whilst this is generally known, it is not easy, except by knowledge derived from experiment, to estimate its amount. It is usual in estimating the tractive effort of a locomotive to assume that the pressure in the cylinders will be from 75 per cent. to 90 per cent. of the boiler pressure, according to the individual judgment, and in the following comparisons 75 per cent. is the value that has been assumed, the figure adopted by Mr. S. W. Johnson in his presidential address, 1898.

The ultimate limit of the power is the capacity of the boiler provided, and the measure of this will be the area of grate, and in a lesser degree the area of the heating surface. The weight of coal consumed per square foot of grate will depend upon the draught, and in this respect probably all boilers will stand upon an equal footing. Of course, there is the increasing difficulty of firing as the area increases, so that probably the efficiency will be somewhat lower for the largest grates as compared with the medium dimensions. The true value of the heating surface will depend upon its position, a few square feet in the fire-box being very much more valuable than many square feet at the smoke-box ends of the tubes. Further, there is the arrangement of the tubes to consider, for there is good reason to believe that closely packed small tubes, although a ready means of obtaining area, will choke both the circulation of the water and the draught by increasing the resistance of the tubes to the passage of the flue gases. Consequently, when comparing the heating surface allowed in locomotives of different designs, anomalous results may be obtained; and therefore the safest measure of the boiler capacity is the grate area. In the comparisons made in the tables both the heating surface is given and grate area, but the latter should be looked upon as of the first importance. The ratios of the cylinder volume and heating surface and grate areas are given as the most suitable factor for the estimation of the boiler capacity.

The adhesion weight provided is the final factor of importance in the estimation of the ability of a locomotive to perform its duties in all weathers, for unless there is sufficient weight provided to prevent slipping, large cylinders and boilers will not avail. The amount of adhesion per ton of the weight on the driving wheels is a quantity that depends upon the state of the weather, and somewhat upon the size of the wheels. In average weather, and for wheels about 7ft. diameter, 450 lb. per ton may be safely reckoned upon, and for wheels of 5ft. diameter the figure is about 350 lb. In bad weather the amount is much reduced, whereas in good weather it may be much greater.

No attempt has been made to combine these factors into one comprehensive factor, which should give the power of a locomotive at a glance, as the task is at the moment scarcely feasible, but a consideration of the factors for different designs will enable one to form a fair opinion of the way that each may be expected to perform under given conditions.

Some typical cases have been taken from British practice, and the several factors calculated to illustrate the manner in which this comparison may be effected, and incidentally examples will be given of the manner in which these factors will enable the preliminaries for a new design to be easily and quickly laid down.

The first column indicates the type on the now generally understood wheel plan; followed by columns in which the total heating surface and grate area are given. From this data the cylinder capacity is calculated and entered in column 4. The formula used is:—

$$\frac{d^2 \times \pi}{144 \times 4} \times 2 \times \frac{S}{12} \times N \times \frac{5280}{D \times \pi} = V;$$

where d = diameter of cylinders in inches,
S = stroke " "
N = number of cylinders,
D = diameter of the driving wheels in feet,
V = total displacement of all pistons per mile in cubic feet.

The two succeeding columns give the total heating surface and the grate area provided, each in square feet; from these the ratios-cylinder capacity ÷ heating surface, and cylinder capacity ÷ grate area, are tabulated. It is obvious that the steam produced will be proportional to the amount of coal consumed, and this will be measured by the area of the grate, whilst the demands for steam will be proportional to the cylinder volume per unit distance. In Table I. this grate factor is 199, and in Table III. 192—each in the first line. An examination of the cylinder capacity shows that the cylinder capacities of each are equal, but the latter engine would stand more forcing than the former, and to that extent is the more powerful. The meaning of these numbers is—for each mile 192 cubic feet will be swept out by the pistons for each square foot of grate area. The second factor is given and has a similar meaning, but not so much importance can be assigned to it for the reasons already given, but it should assist us in forming some idea of the relative amounts allowed in various cases.

The five succeeding columns give data relating to the actual capacity of the boilers, and have been obtained from the paper by Mr. G. J. Churchward.* The amount of spray that will be formed as the steam bubbles rise and burst at the surface must in some degree depend upon the amount of area provided, and for this reason the water-line area has been quoted. The ratios—Water line area ÷ grate area has been calculated, also cylinder capacity ÷ water-line area, for each of these are in a way a measure of the probability of priming. The steam space has been quoted, for the lesson was taught in the early days of torpedo boat work that there was a minimum

TABLE I.

Type.	Cylinders, diameter × stroke.	Driving wheels, diameter.	Cylinder volume per mile.	Total heating surface.	Grate area.	Cylinder volume divided by: Heating surface.	Cylinder volume divided by: Grate area.	Steam space in cub. ft.	Water-line area in sq. ft.	Cylinder vol. divided y water-line area.	Water-line area divided by grate area.	Steam space divided by cylinder volume.	Boiler pressure, lb. per sq. in.	Total tractive force.	Calculated weight on driving wheels.	Actual weight on driving wheels.	Act. weight Cal. weight	Engine No. or name of class.
	in.	ft. in.	cub. ft.	sq. ft.	sq. ft.									lb.	tons.	tons.		
2-4-0	17 × 24	6 6	3260	1363	16·4	2·39	199	—	—	—	—	—	140	9,337	20·75	23·4	1·127	2204
2-4-0	18 × 24	6 0	3960	1469	19·01	2·69	208	—	—	—	—	—	160	12,960	28·00	28·8	1·028	3225
4-4-0	20 × 26	7 0	4561	1561	20·8	2·92	219	—	—	—	—	—	160	14,926	33·17	31·5	0·950	"Gooch"
4-4-0	18 × 26	6 8½	3838	951*	18·32	—	209	—	—	—	—	—	180	14,130	31·39	32·7	1·041	"Badminton"
4-4-0	18 × 26	6 8½	3838	1520	23·65	2·52	162	—	—	—	—	—	180	14,130	31·39	33·5	1·067	"Atbara"
4-4-0	18 × 26	6 8½	3838	1818	20·56	2·11	187	76·2	79·81	48·08	3·882	0·01986	200	15,700	34·89	34·0	0·9745	"Cities"
4-4-0	18 × 30	6 8½	4428	1818	20·56	2·43	215	76·2	79·81	48·08	3·882	0·01986	200	19,320	42·93	34·3	0·799	"Counties"
4-4-2	18 × 30	6 8½	4428	2143	27	2·07	164	97·7	102¼	43·31	3·772	0·02207	225	20,370	45·28	39·0	0·861	"Atlantics"
4-6-0	18 × 30	6 8½	4428	2143	27	2·07	164	97·7	102¼	43·31	3·772	0·02207	225	20,370	45·28	51·2	1·201	"Albions"

* Serve tubes.

TABLE II.

Type.	Cylinders, diameter × stroke.	Driving wheels, diameter.	Cylinder volume per mile.	Total heating surface.	Grate area.	Cylinder volume divided by: Heating surface.	Cylinder volume divided by: Grate area.	Steam space.	Water-line area.	Cylinder vol. divided by water-line area.	Water-line area divided by grate area.	Steam space divided by cylinder volume.	Boiler pressure, lb. per sq. in.	Total tractive force.	Calculated weight on driving wheels.	Actual weight on driving wheels.	Act. weight Cal. weight	Engine No. or name of class.
	in.	ft. in.	cub. ft.	sq. ft.	sq. ft.			cub. ft.	sq. ft.					lb.	tons.	tons.		
0-4-2	17½ × 24	5 6	4083	916	16·25	4·46	251	—	—	—	—	—	140	11,690	25·98	26·8	1·031	"Stirling" 561
2-4-0	17½ × 26	6 6	3744	929	16·25	4·03	230	—	—	—	—	—	140	10,720	23·82	27·5	1·154	,, 869
4-4-0	17½ × 26	6 7½	3672	1124	17·8	3·26	206	—	—	—	—	—	170	12,770	28·38	27·9	0·983	"Ivatt" 400
2-4-0	17½ × 26	6 7½	3672	1124	17·8	3·26	206	—	—	—	—	—	170	12,770	28·38	28·6	1·008	,, 1061
4-4-2	19 × 24	6 7½	3996	1442	26·75	2·77	149	—	—	—	—	—	175	14,310	31·79	31·0	0·975	,, 990
4-4-0	17½ × 26	6 7½	3672	1250	20·8	2·94	176	—	—	—	—	—	170	12,770	28·38	31·0	1·092	,, 1321
4-4-2	18¾ × 24	6 7½	3890	2500	30·9	1·56	126	66·03	92·11	42·23	2·981	0·01697	175	13,930	30·95	36·0	1·163	,, 251

TABLE III.

Type.	Cylinders, diameter × stroke.	Diameter of driving wheels.	Cylinder volume per mile.	Total heating surface.	Grate area.	Cylinder volume per mile divided by: Heating surface.	Cylinder volume per mile divided by: Grate area.	Boiler pressure, lb. per sq. in.	Tractive force.	Calculated weight on driving wheels.	Actual weight on driving wheels.	Act. weight Cal. weight	Name or number of class.
	in.	ft. in.	cub. ft.	sq. ft.	sq. ft.				lb.	tons.	tons.		
2-4-0	17 × 24	6 6	3260	1088	17	2·99	192	140	9,337	20·75	24·06	1·159	No. 800
4-4-0	17½ × 23	6 6	3744	1223	17·5	3·06	214	140	10,718	23·84	26·08	1·130	,, 1315
4-4-0	18 × 26	6 9	3815	1142	17·5	3·34	218	140	10,920	24·27	27·35	1·127	,, 1532
4-4-0	18 × 26	7 0	3678	1260	17·5	2·92	210	160	12,034	26·69	28·10	1·053	,, 1757
4-4-0	19 × 26	7 0	4099	1122	17·5	3·65	234	140	11,730	26·08	28·00	1·074	,, 1668
4-4-0	19 × 26	7 0	4099	1205	19·5	3·40	210	160	13,409	29·79	29·92	1·044	,, 150
4-4-0	19½ × 26	6 9	4315	1519	25·0	2·841	173	180	16,470	36·62	34·10	0·931	,, 2607
4-4-0	19½ × 26	6 9	4315	1455	25·0	2·96	173	200	18,310	40·68	35·5	0·873	,, 863
4-4-0	19 × 26	6 6½	4385	1557	28·4	2·82	154	220	19,730	43·85	38·75	0·884	,, 990

* See Proceedings Mechanical Engineers, London, p. 165, vol ii., 1906; and THE ENGINEER, pp. 189, 204, 205, 288, vol. ci., January-June, 1906.

ratio of steam space and cylinder capacity that must not be overlooked, unless trouble was desired each time the rate of working was disturbed, and it is quite possible that a similar limit in locomotive practice exists. On this point it is interesting to note that Swindon allows 3.9 and 3.8 square feet of water-line area per square foot of grate, whilst at Doncaster this figure is 3 (see Tables I and II.). But in this connection it must be remembered that Swindon engines have no steam dome or perforated internal pipe, taking their steam supply into the open end of the pipe direct; whilst the Doncaster-built engine has a steam dome as usual. Does this mean that to obtain dry steam with a dome the requisite water-line surface may be smaller? The Swindon boiler is of the Belpaire type, and so may account for the larger surface, and consequently these figures may not have the significance suggested; any way, the amount of data available is not sufficient to permit any conclusions.

The last group of columns relate to the adhesion weight. The total tractive force has been calculated from the formula—

$$\frac{d^2 \times s}{2 \times D} \times N \times 0.75 \times P = T;$$

where d, s, and N have the same significance as before, and

P equals the boiler pressure.
T equals tractive effort.

The proportion taken—75 per cent. of the boiler pressure—is lower than is sometimes used, but it is the figure taken by Mr. S. W. Johnson in his presidential address to the Institute of Mechanical Engineers, 1898, and for the purposes of comparison is all that is required in this discussion. The following column is obtained by assuming that the average value of the friction between the drivers and the rails is 450 lb. The calculated load on the drivers in tons is equal to $T \div 450 = W$ tons, say. The ratio, actual load on the drivers in tons $\div$ W, is the factor showing the comparative abilities to haul a load in bad weather. It is asserted that the driving wheels are continually slipping more or less in all weathers, and there can be no doubt but that there is some value of this factor when this imperceptible slipping will rapidly increase. Some guide to this critical value may be obtained from a consideration of the penultimate column of Table III. It will be seen that the values in successive designs seem to diminish, but are afterwards followed by an increase. This table shows the values used by the Midland Company's designers. The first design quoted is No. 800, where the value is 1.159, and this diminishes slowly down to 0.873 in the case of No. 863; but in the next design, No. 990, it has increased again to 0.884. On the Great Western the "Atlantics" are being altered to six-wheeled coupled type, because they are not so reliable with heavy fast trains as the "Albions" have proved themselves to be. The factor for the "Atlantics" is 0.861, slightly lower than the Midland minimum noticed above, so that it would seem that the value for reliable work should not be less than about 0.9. When it is much less inconsistent running is to be expected.

During recent years a remarkable development of locomotive powers has been provided by the locomotive department of the Great Western Company to meet the increasing demands of the traffic. For many years the single-wheel type was exclusively employed for all the best trains, and the work done was of a very high character, many very fine records standing to the credit of the single-wheel engines employed. There were several types of coupled engines employed on various sections of the company's system doing good work within their capacities, but in the Table I., data referring to the modern types only have been used, whilst the single-wheeled designs are dealt with in a later table.

An examination of this table is very instructive. First notice the very rapid increase of the cylinder capacity provided in the first three designs representing an augmentation of 40 per cent., whilst the proportion of the boilers was reduced 9 per cent., as measured by the grate area factor. Hence, if the "Gooch" engines were put to work, trains of equal average speed and proportionately loaded, the boilers would have to supply more steam than the earlier types per unit of fuel consumed; otherwise they would run themselves out of breath. It is, of course, possible that Mr. Dean's intention in this design was to make more efficient use of the steam in the big cylinders, and so obtain an increase of economy in running; but it is generally understood that these engines have proved to be very sluggish runners, but capable of dealing with heavy trains at moderate speeds. The 3225 class have done much excellent work with the expresses between Shrewsbury and Bristol, and in the new type following the "Gooches" it would appear that a return was made to the proportions of 3225. In the new "Badmintons" the allowance of fire grate area is the same, and the cylinder capacity was reduced 16 per cent. as compared with the "Gooches," and nearly 4 per cent. less than the 3225 class. In the "Gooch" the adhesion factor was reduced to 0.950, but in the new "Badminton" it was increased again to 1.041; it is evident, therefore, that the "Badminton" was a much more powerful engine than the "Gooch," although its total tractive force on paper is less, because it had greater boiler power and a greater adhesion factor, enabling it to make better use of its cylinder capacity than was possible for the "Gooch" type; hence it would prove to be a more reliable type for use in all weathers, and in practice this was realised, for it at once proved its capacity for work, as many noteworthy achievements were immediately placed to its credit.

The "Atbara" type soon followed, and was a further development; the cylinder volume remained the same, but the boiler capacity was again increased beyond any of the preceding types, and the amount of adhesion allowed was greater. These engines proved their worth immediately, so that they were speedily multiplied; the "Badmintons," although performing so admirably, were outclassed and became obsolete. The next variant onwards was the type known as the "Cities," in which the chief variation made was an increase of the boiler pressure and of the total heating surface allowed, but this was accompanied by a decrease in the grate area and of the adhesion factor, the latter falling to only a little more than in the "Gooch." This class has proved to be very satisfactory in actual work, and is still being multiplied, the later engines being known as the "Flower" type.

The next type in the order of development was the "Counties," and in these engines the cylinder capacity is increased nearly to the same size as that of the "Gooch," and were placed outside the frames; the boiler was the same as that supplied to the "Cities," and is in consequence a retrogression; the adhesion factor is also much less; in fact, it is almost as low as in some single-wheeled types. These engines have, however, done some excellent work, but have not been multiplied on the same scale as the "Cities." The "Counties" were succeeded by the "Atlantics," which

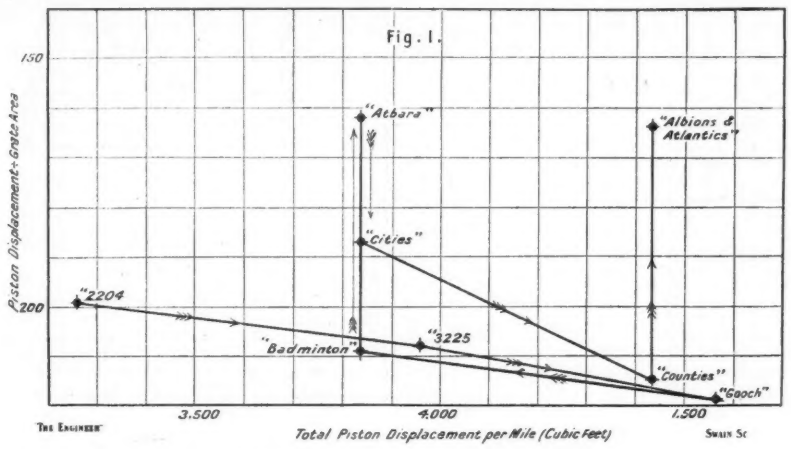


Fig. 1—EVOLUTION OF G.W.R. LOCOMOTIVES

are similar to the "Counties" as regards cylinder capacity, but have larger boilers, which are on the same liberal scale as with the "Atbaras." The weight on the drivers was increased, but the value of the factor was still relatively low, and this latter defect has apparently led to their reconstruction as the "Albions," which are six-wheeled coupled, and in this form they have proved to be most successful in every way, and are being multiplied rapidly.

Briefly, the lines along which Messrs. Dean and Churchward appear to have moved may be summed up thus:—

First, a reduction of the ratios:—

$$\frac{\text{Cylinder volumes}}{\text{Grate area}} \quad \text{and} \quad \frac{\text{Tractive effort}}{\text{Adhesive weight}}$$

Secondly, a return to greater values of these ratios. Thus the "Gooch," the "Counties" and the "Atlantics" each mark the "low-water levels" of the ratios and 2204, the "Atbaras," the "Cities" and the six-coupled types are the several succeeding high levels reached. It is interesting to note that the cylinder capacities of the six-coupled is still less than that of the "Gooch," although it is quite obvious that the latter class could not do the work of the former. The curves, Figs. 1 and 2, illustrate the movement during the evolution of the latest type of engine. In Fig. 1 the ratio of the grate area factor is shown, and Fig. 2 the adhesion factor, both being plotted on a basis of cylinder displacement, and the progress is shown by the arrow lines in each case.*

This table has been discussed at length in order to show how the tables are constructed and what information may be obtained from them, also for the reason that the engines of the Great Western Company have probably in recent years been doing work better than many of its contemporaries, and for that reason alone are well worth the attention that has been given them.

A point worth notice when estimating the probable adhesion factor suitable for any given case is the character of the road over which the engine will have to work, which must have full consideration, as in some cases a lower value may give quite satisfactory results in actual practice. At starting and at low speeds the engine may be working with little or no expansion, and yet the boiler be quite able to supply all the steam required, but as the speed increases the engine must be notched up; thus, although the engine revolutions are greater, the amount of steam required will be but little different from that at the lower rate—*i.e.*, the engine may work at constant power, although running at varying speeds. Thus a small cylinder capacity may, with a suitable boiler, use steam all through the stroke when starting a load, and give a nominally high tractive effort, and so accelerate a load quickly, and afterwards when speed is attained an earlier cut-off will give plenty of power to keep the train up to speed. Further, this engine would be able to run with a later cut-off when climbing a bank, and so maintain its average speed more easily than an engine having nominally greater tractive effort, due to a greater cylinder capacity only. Further, as an engine gathers speed the mean pressure in the cylinders fall when the cut-off is maintained at the same point,* consequently the tractive effort at the draw-bars is also a constantly decreasing quantity with increasing speed, so that there are reasons why an engine, such as the "Atbaras," should be much better than the "Badmintons," solely from the more adequate boiler power that this class possesses, and the consequent ability to run fast with a later cut-off. Another example is the Great Northern Atlantic No. 251, which appear to be capable of doing quite as good work as many engines with much larger cylinder capacity, and the secret is the large grate area factor. From a consideration of these points one would expect the "Cities" to maintain a higher speed up the banks than the "Atbaras." Also if the "Counties" were set to work the same trains as the "Cities" they would perform satisfactorily, but if they were pressed by heavy loads, or bad weather, then in all probability they would run out of breath by reason of their smaller adhesive weight, which would allow slipping to occur, and so prevent them taking full advantage of their superior cylinder capacity. This was probably the reason why they have given rise first to the Atlantic type, in which the same engine receives a larger boiler, so getting a better steam supply, only to find that they must have more adhesion to prevent slipping, so that the six-coupled engine was the necessary result.

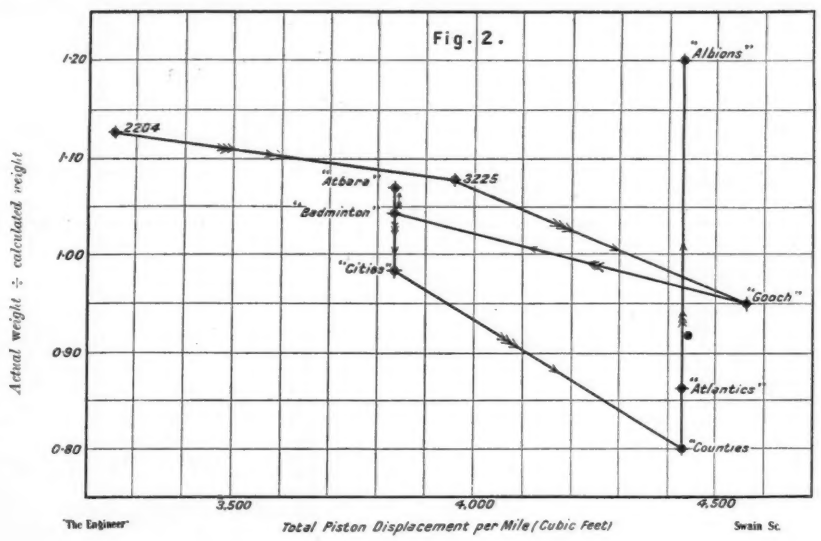


Fig 2—EVOLUTION OF G.W.R. LOCOMOTIVES

* "3225" appears to be wrongly plotted in Fig. 2.—ED. THE E.

* See Dalby, Proc. Inst. C.E., p. 329, vol. clxiv.

IN her speed trials recently, the North Dakota, the latest Dreadnought for the United States Navy, which is fitted with Parsons turbine engines, succeeded in attaining a speed of 22¼ knots.

MARCONI WIRELESS TELEGRAPHY.*

By Mr. G. Marconi.

THE discoveries connected with the propagation of electric waves over long distances, and the practical applications of telegraphy through space, which have gained for me the supreme honour of sharing the Nobel prize for Physics, have been to a great extent the result of one another.

The application of electric waves to the purposes of wireless telegraphic communication between distant parts of the earth, and the experiments which I have been fortunate enough to be able to carry out on a larger scale than is attainable in ordinary laboratories, have made it possible to

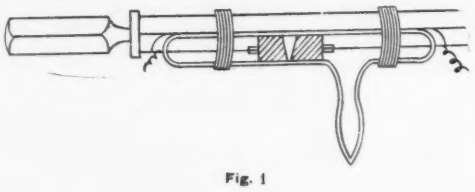


Fig. 1

investigate phenomena and note results often novel and unexpected. In my opinion many facts connected with the transmission of electric waves over great distances still await a satisfactory explanation, and I hope to be able in this lecture to refer to some observations which appear to require the attention of physicists.

In sketching the history of my association with radio-telegraphy, I might mention that I never studied physics or electrotechnics in the regular manner, although as a boy I was deeply interested in these subjects. I did, however, attend one course of lectures on Physics under the late Professor Rosa, at Livorno, and I was, I think I might say, fairly well acquainted with the publications of that time dealing with scientific subjects, including the works of Hertz, Branly and Righi. At my home near Bologna, in Italy, I commenced early in 1895 to carry out tests and experiments

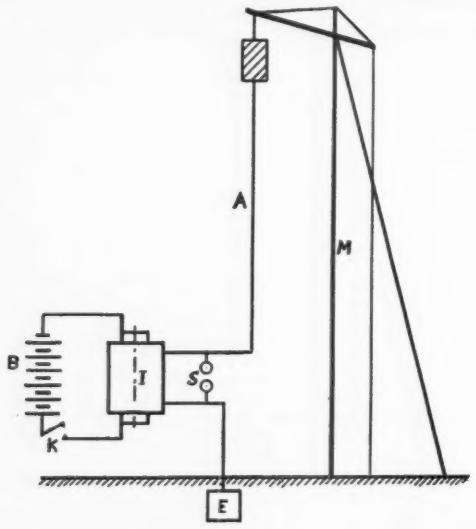


Fig. 2

with the object of determining whether it would be possible by means of Hertzian waves to transmit to a distance telegraphic signs and symbols without the aid of connecting wires. After a few preliminary experiments with Hertzian waves I became very soon convinced that if these waves or similar waves could be reliably transmitted and received over considerable distances a new system of communication would ecobme available possessing enormous advantages over flash-lights and optical methods, which are so much dependent for their success on the clearness of the atmosphere. My first tests were carried out with an ordinary Hertz oscillator and a Branly coherer as detector, but I soon found out that the

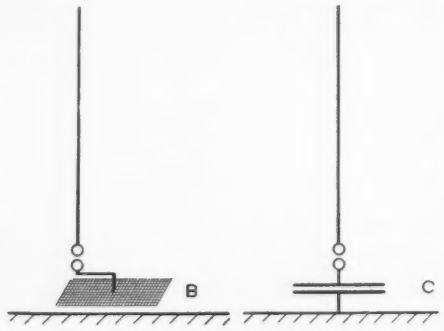


Fig. 4

Branly coherer was far too erratic and unreliable for practical work.

After some experiments I found that a coherer, constructed as shown in Fig. 1, and consisting of nickel and silver filings placed in a small gap between two silver plugs in a tube, was remarkably sensitive and reliable. This improvement, together with the inclusion of the coherer in a circuit tuned to the wave-length of the transmitted radiation, allowed me gradually to extend up to about a mile the distance at which I could affect the receiver.

* Address delivered in Stockholm on 11th December by Mr. Marconi on the occasion of the awarding of his share of the Nobel prize.

Another, now well-known, arrangement which I adopted was to place the coherer in a circuit containing a voltaic cell and a sensitive telegraph relay actuating another circuit, which worked a tapper or trembler and a recording instrument. By means of a Morse telegraphic key placed in one of the circuits of the oscillator or transmitter, it was possible

Fig. 5

to emit long or short successions of electric waves, which would affect the receiver at a distance and accurately reproduce the telegraphic signs transmitted through space by the oscillator. With such apparatus I was able to telegraph up to a distance of about half a mile. Some further improvements were obtained by using reflectors with both the transmitters and

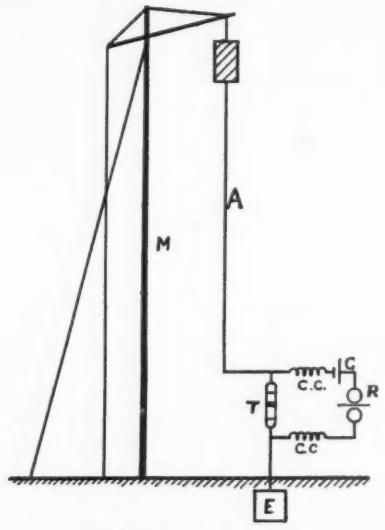


Fig. 3

receivers, the transmitter being in this case a Righi oscillator. This arrangement made it possible to send signals in one definite direction, but was inoperative if hills or any large obstacle happened to intervene between the transmitter and receiver.

In August, 1895, I discovered a new arrangement which not only greatly increased the distance over which I could

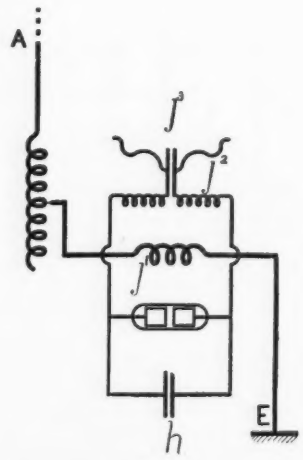


Fig. 6

communicate, but also seemed to make the transmission independent from the effects of intervening obstacles. This arrangement consisted in connecting one terminal of the Hertzian oscillator, or spark producer, to earth, and the other terminal to a wire or capacity area placed at a height above the ground, and in also connecting at the receiving end one terminal of the coherer to earth and the other to an elevated conductor.—Figs. 2 and 3. I then began to examine the relation between the distance at which the transmitter could affect the receiver, and the elevation of the capacity areas above the earth, and I very soon definitely ascertained that the higher the wires or capacity areas the greater the distance over which it was possible to telegraph.

Thus I found that when using cubes of tin about 30 cms. side as elevated conductors or capacities, placed at the top of poles 2 m. high, I could receive signals at 30 m. distance, and when placed on poles 4 m. high at 100 m., and at 8 m. high at 400 m. With larger cubes 100 cms. side, fixed at a height of 8 m., signals could be transmitted 2400 m. all round.[1] These experiments were continued in England, where, in September, 1896, a distance of 1½ miles was obtained in tests carried out for the British Government at Salisbury. The distance of communication was extended to four miles in March, 1897, and in May of the same year to nine miles. Tape messages obtained during these tests, signed by the British Government officers who were present, are exhibited. In all these experiments a very small amount of electrical power was used, the high-tension current being produced by an ordinary Rhumkoff coil. The results obtained attracted a good deal of public attention at the time, such distances of communication being considered remarkable.

As I have explained, the main feature in my system consisted in the use of eleva ed capacity areas, or vertical wires, attached to one pole of the high-frequency oscillators and receivers, the other pole of which was earthed. The practical value of this innovation was not understood by many physicists for quite a considerable period, and the results which I obtained were by many erroneously considered simply due to efficiency in details of construction of the receiver, and to the employment of a large amount of energy. Others did not overlook the fact that a radical change had been introduced by making these elevated capacities and the earth form part of the high-frequency oscillators and receivers. Professor Ascoli, of Rome, gave a very interesting theory of the mode of operation of my transmitters and receivers in

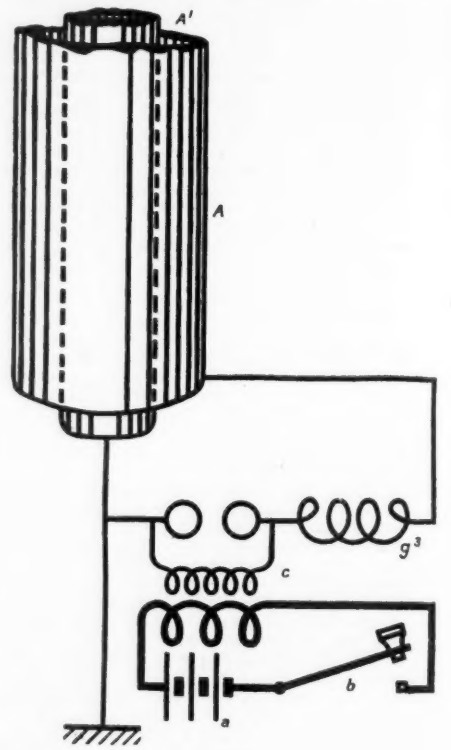


Fig. 7

the *Elettricista* (Rome) issue of August, 1897, in which he correctly attributed the results obtained to the use of elevated wires or antennas. Professor A. Slaby, of Charlottenburg, after witnessing my tests in England in 1897, came to somewhat similar conclusions.[2]

Many technical writers have stated that an elevated capacity at the top of the vertical wire is unnecessary. This is true if the length or height of the wire is made sufficiently great, but as this height may be much smaller for a given distance if a capacity area is used, it is more economical to use such capacities, which now usually consist of a number of wires spreading out from the top of the vertical conductor.

The necessity or utility of the earth connection has been sometimes questioned, but in my opinion no practical system of wireless telegraphy exists where the instruments are not connected to earth. By "connecting to earth" I do not necessarily mean an ordinary metallic connection as used for ordinary wire telegraphs. The earth wire may have a condenser in series with it, or it may be connected to what is really equivalent, a capacity area placed close to the surface of the ground—Fig. 4. It is now perfectly well known that a condenser, if large enough, does not prevent the passage of high-frequency oscillations, and therefore in these cases the earth is for all practical purposes connected to the antennæ. After numerous tests and demonstrations in Italy and in England over distances varying up to 40 miles, communication was established for the first time across the English Channel between England and France in March, 1899.[3] (Fig. 5.)

From the beginning of 1898 I had practically abandoned the system of connection shown in Fig. 2, and instead of joining the coherer or detector directly to the aerial and earth, I connected it between the ends of the secondary of a suitable oscillation transformer containing a condenser and tuned to the period of the electrical waves received. The primary

[1] See "Journal" of the Institution of Electrical Engineers, London, 1899. Vol. XXVIII., page 278.

[2] See A. Slaby, "Die Funkentelegraphie," Berlin, 1897, Verlag von Bronhard Simion; also A. Slaby, "The New Telegraphy," the *Century Magazine*, April, 1898, Vol. LV., page 867.

[3] See *Journal* of the Institution of Electrical Engineers, 1899, London, Vol. XXVIII., p. 291.

of this oscillation transformer was connected to the elevated wire and to earth—Fig. 6. This arrangement allowed of a certain degree of syntony, as by varying the period of oscillation of the transmitting antennæ it was possible to send messages to a tuned receiver without interfering with others differently syntonised.[4]

As it is now well known, a transmitter consisting of a vertical wire discharging through a spark gap is not a persistent

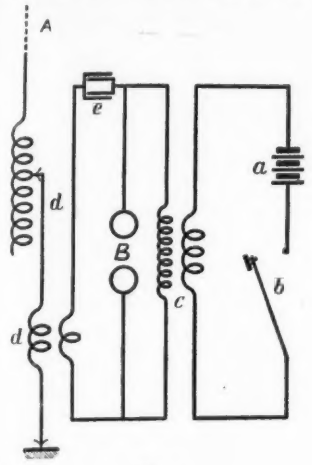


Fig. 8

oscillato the radiation it produces is strongly damped. Its electrical capacity is comparatively so small and its capability of radiating energy so large that its oscillations decrease or die off with great rapidity. In this case receivers or resonators of a considerably different period or pitch are likely effected by it. Early in 1899 I was able to improve the

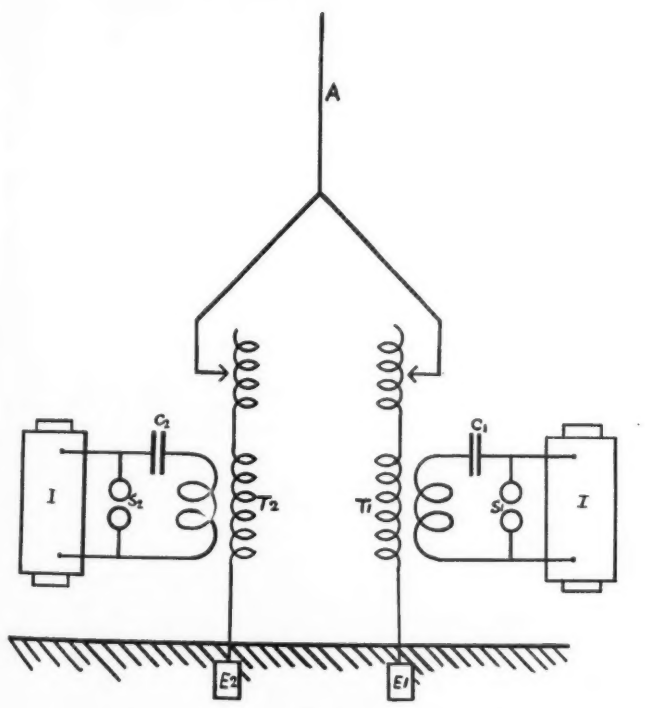


Fig. 9

resonance effects obtainable by increasing the capacity of the elevated wires by placing adjacently to them earthed conductors, and inserting in series with the aerials suitable inductance coils[5]. By these means the energy storing capacity of the aerial was increased, whilst its capability to radiate was decreased, with the result that the energy set in motion by the discharge formed a train or succession of feebly damped oscillations. A modification of this arrangement, by which excellent results were obtained, is shown in Fig. 7.

In 1900 I constructed and patented transmitters which consisted of the usual kind of elevated capacity area and earth connection, but these were inductively coupled to an oscilla-

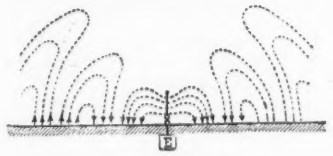


Fig. 11

tion circuit containing a condenser, an inductance and a spark gap, the conditions which I found essential for efficiency being that the periods of electrical oscillation of the elevated wire or conductor should be in time or resonance with that of the condenser circuit—Fig. 8[6]. The circuits, consisting of

[4] British Patent No. 12326 of June 1st, 1898; also No. 6922 of April 1st, 1899.

[5] See "Etat Actuel et Progres de la Telegraphie sans Fil" by A. Blondel and G. Ferrie, read at the Congres Internationa d'Electricite, Paris, 1900; also "Journal" of the Society of Arts, 1901, Vol. XLIX, page 509.

[6] See British Patent No. 7777 of 26th of April, 1900; also "Journal" of the Society of Arts, Vol. XLIX., May 17th, 1901, page 510-511.

the oscillating circuit and radiating circuit, were more or less closely "coupled" by varying the distance between them. By the adjustment of the inductance inserted in the elevated conductor and by the variation of the capacity of the condenser circuit the two circuits were brought into resonance, a condition which, as I have said, I found essential in order to obtain efficient radiation.

Part of my work regarding the utilisation of condenser circuits in association with the radiating antennæ was carried out simultaneously to that of Professor Braun, without, however, either of us knowing at the time anything of the contemporary work of the other.

A syntonic receiver has already been shown in Fig. 6, and consists also of a vertical conductor or aerial, connected to earth through the primary of an oscillation transformer, the secondary circuit of which included a condenser and a detector, it being necessary that the circuit containing the aerial and the circuit containing the detector should be in electrical resonance with each other, and also in tune with the periodicity of the electric waves transmitted from the sending station. It is also possible to couple to one sending conductor several differently tuned transmitters, and to a receiving wire a number of corresponding receivers, as is shown in Figs. 9 and 10, each individual receiver responding only to the radiations of the transmitter with which it is in resonance.

At the time (twelve years ago) when communication was first established by means of radiotelegraphy between England and France, much discussion and speculation took place as to whether or not wireless telegraphy would be practicable for much longer distances than those then covered, and a somewhat general opinion prevailed that the curvature of the earth would be an insurmountable obstacle to long-distance transmission, in the same way as it was, and is, an obstacle to signalling over considerable distances by means of light flashes. Difficulties were also anticipated as to the possibility of being able to control the large amount of energy which it appeared would be necessary to cover long distances. What often happens in pioneer work repeated itself in the case of radiotelegraphy—the anticipated obstacles or difficulties were either purely imaginary or else easily surmountable, but in their place unexpected barriers manifested themselves, and recent work has been mainly directed to the solution of problems presented by difficulties which were certainly neither expected nor anticipated when long distances were first attempted.

With regard to the presumed obstacle of the curvature of the earth, I am of opinion that those who anticipated difficulties in consequence of the shape of our planet had not taken sufficient account of the particular effect of the earth connection to both transmitter and receiver, which earth connection introduced effects of conduction which were generally at that time overlooked. Physicists seemed to consider for a long time that wireless telegraphy was solely dependent on the effects of free Hertzian radiation through space, and it was years before the probable effect of the conductivity of the earth between the stations was satisfactorily considered or discussed.

Lord Rayleigh, in referring to Transatlantic telegraphy, stated, in May, 1903: "The remarkable success of Marconi in signalling across the Atlantic suggests a more decided bending or diffraction of the waves round the protuberant earth than had been expected, and it imparts a great interest to the theoretical problem."[7]

Professor J. A. Fleming, in his book on "The Principles of Electric Wave Telegraphy,"[8] gives diagrams showing what is now believed to be the diagrammatic representation of the detachment of semi-loops of electric strain from a simple vertical wire—Fig. 11. As will be seen, these waves do not propagate in the same manner as free radiation from a classical Hertzian oscillator, but glide along the surface of the earth. Professor Fleming further states in the above-quoted work:—"The view we here take is that the ends of the semi-loops of electric force, which terminate perpendicularly on the earth, cannot move along unless there are movements of electrons in the earth corresponding to the wave-motions above it. From the point of view of the electronic theory of electricity, every line of electric force in the ether must be either a closed line or its ends must terminate on electrons of opposite sign. If the end of a line of strain abuts on the earth and move, there must be atom-to-atom exchange of electrons, or movements of electrons in it. We have many reasons for concluding that the substances we call conductors are those in which free movements of electrons can take place. Hence the movements of the semi-loops of electric force outwards from an earthed oscillator or Marconi Aërial is hindered by bad conductivity on the surface of the earth and facilitated over the surface of a fairly good electrolyte, such as sea water."

[7] See "Proceedings" of the Royal Society, Vol. 72, May 28th, 1903

[8] See page 348 (published by Longmans, Green and Co., London. 1906.)

Professor[9] Zenneck has carefully examined the effect of

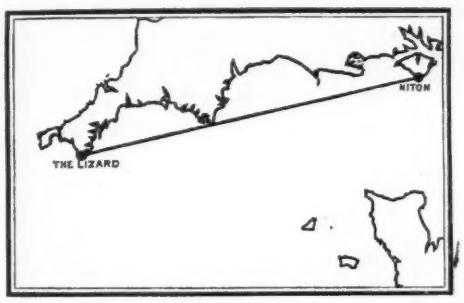


Fig. 12

earthed transmitting and receiving aërials, and has endeavoured to show mathematically that when the lines of electrical force, constituting a wave front, pass along a surface of low specific inductive capacity, such as the earth, they become inclined forward, their lower ends being retarded by the resistance of the conductor to which they are attached. It therefore seems well established that wireless telegraphy, as practised at the present day, is dependent for its conductivity of the earth, and that the difference in

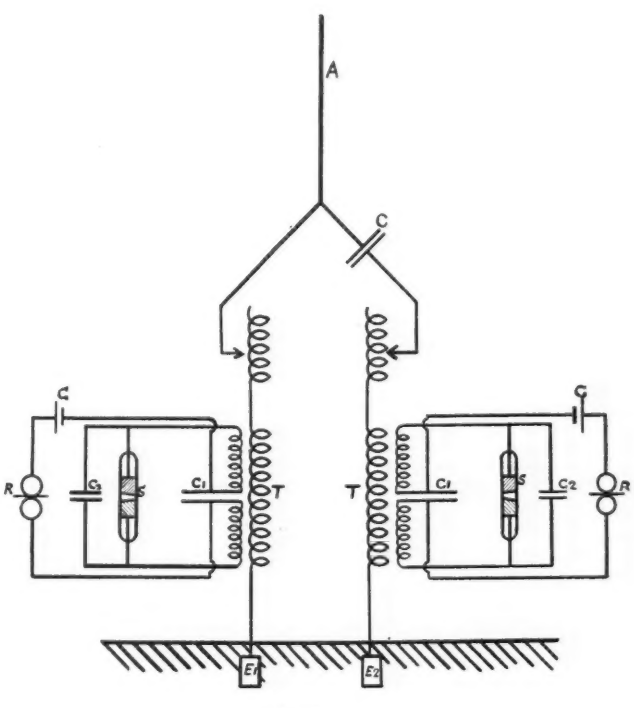


Fig. 10

operation over long distances on the conductivity between the surface of the sea and land is sufficient to explain the increased distance obtainable with the same amount of energy in communicating over sea as compared to over land.

I carried out some tests between a shore station and a ship at Poole, in England, in 1902, for the purpose of obtaining some data on this point, and I noticed that at equal

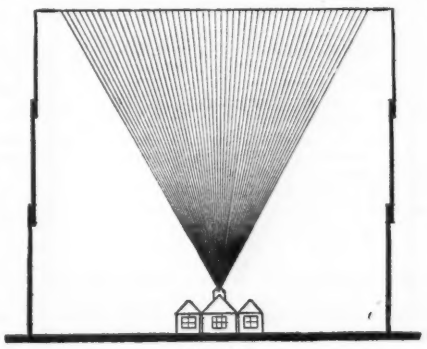


Fig. 13

distances a perceptible diminution in the energy of the received waves always occurred when the ship was in such a position as to allow a low split of sand about 1 kilom. broad to intervene between it and the land station. I therefore

[9] See J. Zenneck. "Annalen der Physik.," 23, 5, p. 846, September 1908. "Physikal Zeitschrift," No. 4, p. 50; No. 17, p. 553.

believe that there was some foundation for the statement so often criticised which I made in my first English patent of June 2nd, 1896, to the effect that when transmitting through the earth or water I connected one end of the transmitter and one end of the receiver to earth.

In January, 1901, some successful experiments were carried out between two points on the South Coast of England 186 miles apart, *i.e.*, St. Catherine's Point, Isle of Wight, and the Lizard, in Cornwall.[10]—Fig. 12. The total height of these stations above sea level did not exceed 100 m., whereas to clear the curvature of earth a height of more than 1600 m. at each end would have been necessary. The results obtained from these tests, which at the time constituted a record distance, seemed to indicate that electric waves produced in the manner I had adopted would most probably be able to make their way round the curvature of the earth, and that therefore even at greater distances, such as those dividing America from Europe, the factor of the earth's curvature would not constitute an insurmountable barrier to the extension of telegraphy through space.

The belief that the curvature of the earth would not stop the propagation of the waves, and the success obtained by syntonic methods in preventing mutual interference, led me in 1900 to decide to attempt the experiment of testing whether or not it would be possible to detect electric waves over a distance of 4000 kiloms., which, if successful, would immediately prove the possibility of telegraphing without wires between Europe and America. The experiment was, in my opinion, of great importance from a scientific point of view, and I was convinced that the discovery of the possibility to transmit electric waves across the Atlantic Ocean, and the exact knowledge of the real conditions under which telegraphy over such distances could be carried out, would do much to improve our understanding of the phenomena connected with wireless transmission. The transmitter erected at Poldhu, on the coast of Cornwall, was similar in principle to the one I have already referred to, but on a very much larger scale than anything previously attempted.[11] The power of the generating plant was about 25 kilowatts.

Numerous difficulties were encountered in producing and controlling for the first time electrical oscillations of such power. In much of the work I obtained valuable assistance from Professor J. A. Fleming, Mr. R. N. Vyvyan, and Mr. W. S. Entwistle. My previous tests had convinced me that when endeavouring to extend the distance of communication, it was not merely sufficient to augment the power of the electrical energy of the sender, but that it was also necessary to increase the area or height of the transmitting and receiving elevated conductors. As it would have been too expensive to employ vertical wires of great height, I decided to increase their number and capacity, which seemed likely to make possible the efficient utilisation of large amounts of energy. The arrangement of transmitting antennæ which was used at Poldhu is shown in Fig. 13, and consisted of a fan-like arrangement of wires supported by an insulated stay between masts only 48 m. high and 60 m. apart. These wires converged together at the lower end, and were connected to the transmitting apparatus contained in a building.

For the purpose of the test, a powerful station had been erected at Cape Cod, near New York, but the completion of the arrangements at that station were delayed in consequence of a storm, which destroyed the masts and antennæs. I therefore decided to try the experiments by means of a temporary receiving station erected in Newfoundland, to which country I proceeded with two assistants about the end of November, 1901.

The tests were commenced early in December, 1901, and on the 12th of that month the signals transmitted from England were clearly and distinctly received at the temporary station at St. John's, in Newfoundland. Confirmatory tests were carried out in February, 1902, between Poldhu and a receiving station on the s.s. Philadelphia, of the American Line. On board this ship readable messages were received by means of a recording instrument up to a distance of 1551 miles, and test letters as far as 2099 miles from Poldhu—Fig. 14.

The tape records obtained on the Philadelphia at the various distances were exceedingly clear and distinct, as can be seen by the specimens exhibited.

These results, although achieved with imperfect apparatus, were sufficient to convince me and my co-workers that by means of permanent stations and the employment of sufficient power it would be possible to transmit messages across the Atlantic Ocean in the same way as they were sent over much shorter distances. The tests could not be continued in Newfoundland owing to the hostility of a cable company, which claimed all rights for telegraphy, whether wireless or otherwise, in that Colony.

(To be continued.)

[10] See "Journal" of the Society of Arts, London, Vol. XLIX., page 512, 1901.

[11] Royal Institution of Great Britain, Lecture by G. Marconi, June 13th, 1902.

CERTIFIED TRACK CHART OF S.S. PHILADELPHIA. AMERICAN LINE.
SHEWING POINTS WHERE Mr G. MARCONI RECEIVED MESSAGES FROM CORNWALL. ENGLAND

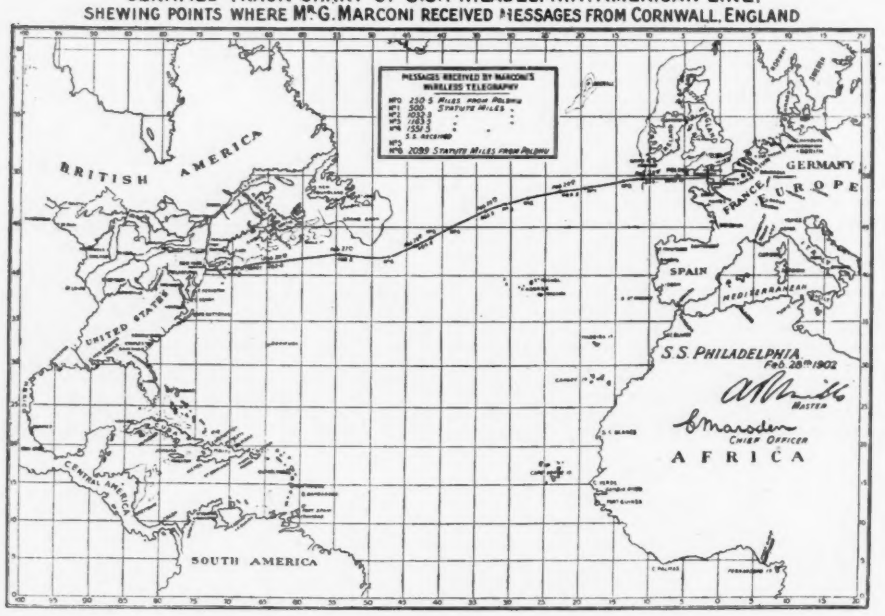


Fig. 14

concern to those responsible for the permanent way. It will be generally known that a check rail is an additional rail provided inside the inner rail on a curve, as in Fig. 2. This will be seen in elevation in the middle illustration, from which it will be appreciated that the check-rail assists in keeping the wheel on the outer side of the curve from mounting the rail and becoming derailed. It may be remarked that the Board of Trade requirements specify that all curves, where the radius is ten chains or less, are to be provided with a check-rail. Naturally, therefore, there must be considerable friction between the wheels and check-rails, and this is greater on an electrically operated than on a steam-worked road, because with the latter the locomotive is the only propelling force, and as it draws the train past the check-rail the wheels of the train are disposed to "give." But with an electric train, on the multiple-unit system, each motor grinds its way through, which leads to considerable wear of both check-rail and wheel.

A remedy for this has, however, been found, and it is one that is equally applicable to steam and electric roads. It has been designed by Mr. E. J. Neachell, the general manager and engineer of the Liverpool Overhead Railway, on which line we recently inspected the apparatus. This line has always been electrically operated, and the troubles arising from check-rails have been particularly manifest there, as the railway has fourteen miles of track, of which one-sixth is on curves, and there is a five minutes' service on each road.

The apparatus will be understood on reference to Fig. 1. Fixed in the "four-foot," near the commencement of a curve, is a grease-box containing graphite or some other lubricant. In this box is a piston, driven forward by a screw actuated by a ratchet wheel. The ratchet wheel is turned by means of a pawl raised, through a series of levers, on the depression of a treadle by the side of the line. The treadle is carried by two or more levers fixed to the sleepers in the "four-foot," and is balanced by another treadle connected to the levers on the opposite end. The levers, not being centrally pivoted, cause the treadle nearer the rail to be normally raised and, being fixed close to the rail, it is depressed by the flange of the wheel of passing vehicles. The treadle may be balanced in other ways, but in the manner illustrated the distribution of weight and of stress is better equalised. As, then, the bar is depressed, the connecting levers and pawl are moved and a turn given to the ratchet wheel, and so the piston is driven forward. At the other end of the grease-box are holes through which the lubricant is forced out on to the inner vertical face of the flange of the wheel. The wheels are thus lubricated, also the check-rails as the wheels pass by them. In the centre of the four-foot is the third rail conveying the electrical power. This is, of course, no part of the apparatus, and each is independent of the other. By arranging the length of the treadle it is possible to actuate the piston for every wheel or every bogie, or only once for each train.

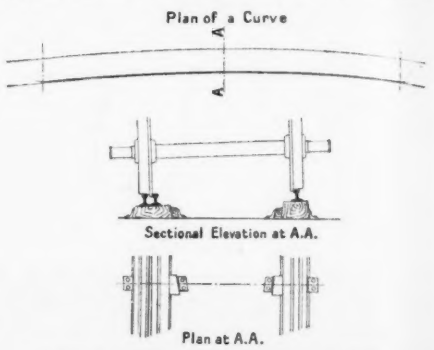


Fig. 2—ARRANGEMENT OF CHECK RAIL

On the overhead railway there is a grease-box at the north end of the line and another at James-street Station. The latter is on the up-line, and we noticed grease on the opposite down-line, which showed that it had been carried to the south end of the line and back again—a distance of six miles—lubricating all the check-rails in the distance. Since the adoption of this apparatus it is estimated that there has been a saving of 50 per cent. in the wear of check-rails, and it is no longer necessary for men to go over the line every night to apply grease by hand. There is also a longer life in the tires, and, necessarily, some reduction in operating power.

The apparatus is, as we have said, equally applicable to steam-worked railways, although the need there is not so great for the reasons given above. The patent rights have been acquired by Graphite Products, Limited, 218-220, Queen's-road, Battersea, London, S.W., which company also manufactures the apparatus.

THE LUBRICATION OF CHECK-RAILS.

SINCE the introduction of electrical traction on railways the wear of check-rails has been a matter of considerable

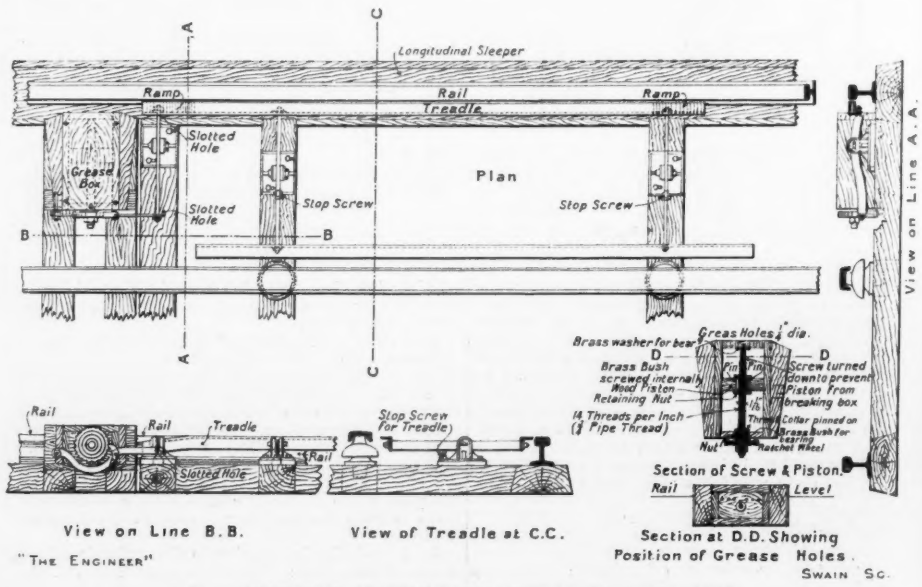


Fig. 1—NEACHELL'S APPARATUS FOR LUBRICATING CHECK RAILS

STERN FRAMES AND BRACKETS OF THE NEW WHITE STAR LINERS.

IN previous issues of THE ENGINEER, and notably those of 27th August and 3rd December of this year, the progress made by Harland and Wolff, Limited, of Belfast, in the construction of the two new mammoth steamships, Olympic and Titanic which they have on order for the New York services of the White Star Line, has been described and illustrated. As is now well known, these vessels will eclipse the new Cunarders in point of size, but their speed will not be so great. For both these new additions to the fleet of the White Star Line, the Darlington Forge Company was entrusted with the manufacture of the cast steel stern frames, brackets, and rudders, and these various pieces are far and away the largest and heaviest marine castings ever produced. The stern frame, rudder, and brackets of the Lusitania and of the Mauretania—which were also supplied by the Darlington Forge Company, and were described and illustrated in THE ENGINEER of September 29th, 1905—had a weight of about 220 tons. The total weight of the stern frame, rudder,

and brackets in each of the new White Star steamships will be approximately 289 tons, made upas follows:—Stern frame 70 tons, after boss arms 74 tons, forward boss arms 45 tons, and rudder 100 tons. The stern frame is of special quality mild cast steel, and is of hollow or "dished" section, constructed in two pieces 63ft. and 37ft. 4in. in length respectively. The scarphs have been so arranged that in the event of any damage occurring to the post it can be removed with a minimum of trouble and without disturbing the riveting in any large portion of the shell plating of the vessel.

Great attention has been paid to the design of the scarphs, months in all. The rudder frame is in five massive castings, bolted together with a forged rudder head, 24in. in diameter, and the stock is of hydraulic-pressed steel.

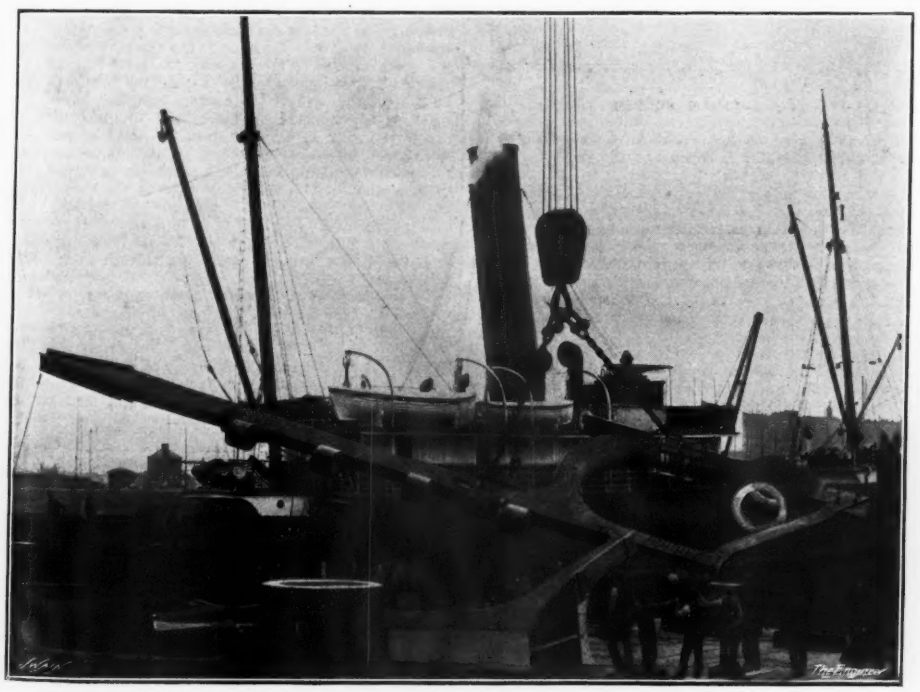
On page 636 we are enabled to show views of the forward and aft brackets of the Titanic, and on this page are reproduced three views of stern frames and boss arms of the Olympic. The three photographs from which these engravings were made were taken on August 10th last.

Owing to their enormous weights and exceptional overall dimensions, a series of elaborate railway arrangements had to be adopted, in order to permit of the safe passage of these

BOSS ARMS OF OLYMPIC BEING WEIGHED

the forward one being of somewhat novel construction, owing to the "dishing" of the post in its vicinity. They were riveted up with rivets of the best Lowmoor iron, and as these were naturally long and extra heavy, special apparatus in the shape of rams had to be employed in this operation.

The boss arms are in two pairs, placed one about 20ft. forward of the other, and they are of exceptional dimensions and special design. They will extend right across the vessel, with the object of forming a very strong girder and of obviating vibration or panting at this part of the ship. These boss arms are of the finest special quality mild cast steel, and each pair is in two pieces, bolted together with strong flanges at the centre line of the vessel. The after one is connected



UPPER PORTION OF STERN FRAME OF OLYMPIC

to a 2in. solid steel bulkhead, whilst the forward one is connected to very stout and broad web frames down the vessel's sides. It will therefore be evident that in addition to their special function of carrying the shafts and propellers, these frames will increase materially the strength of the structure at the after part of the vessel.

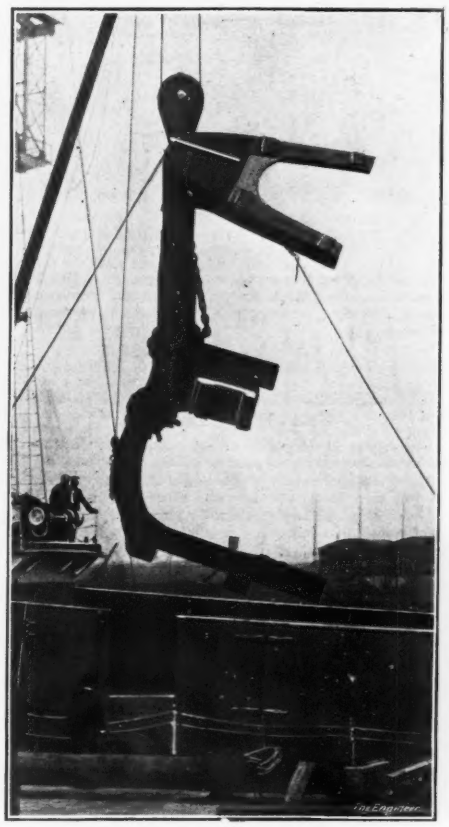
In casting the main piece of stern frame, about 95 tons of molten metal were required, and as now finished its weight is 70 tons. The making of the mould in which the stern frame was cast represented two months' work, and the completion of the finished castings five months more—seven

castings between the Darlington Forge Company's works and the shear legs at the North-Eastern Railway Company's Union Dock at West Hartlepool.

As previously mentioned, the stern frames were, for the purposes of transport, manufactured in two portions, the upper part having a length of 63ft., with the tail-piece 56ft. 0½in. in length, the total weight being about 39½ tons. This casting was loaded upon a 50-ton trolley wagon having a length over buffers of 51ft. 7½in., a bogie wheel base of 5ft., and bogie centres distanced 38.t. 6in. apart. The "well" of the wagon, 25ft. in length, was built up with timber baulks and the load secured by chains and shackles, whilst heavy steel ingots formed counter-balancing weights. The total overhang, on the off or abutment side, was 2ft. 9in., and the tail-piece was slewed round so as better to distribute the load on the wagon, the overhang, measuring from the centre of the wagon, being 16ft. 3in., and the total height of the load above rail level 9ft. 6in. The lower part of the stern frame of the Titanic has a length of 37ft. 4in., the length of the gudgeon being 16ft., and the palm 9ft. wide and 11ft. deep. When loaded upon the 40-ton trolley wagon the overhang amounted to 11ft. 10in. The after boss arms frame was constructed in two parts, and loaded upon 40-ton and 50-ton wagons respectively, These castings have each a total length of 22ft., whilst the boss is 6ft. 3½in. deep and 5ft. 2½in. diameter. The "wells" of the wagons were built up with heavy timbers, and eight-ton steel ingots served as counter-balancing weights. In these instances, although the castings were loaded at an angle, the overhang from the wagon side was 15ft. and 2ft. 6in. on the "off" side. The forward boss arms were also in two parts, of a total weight of about 45 tons. They have a length of 22ft. 3$\frac{9}{16}$in., and the boss is 3ft. 6½in. deep and 6ft. 2in. diameter. They were loaded similarly to the after boss arms.

It was only possible to transport these castings during the lull of traffic on a Sunday, and then only by a temporary re-arrangement of the existing goods train services on the route between Darlington and West Hartlepool, and by observing a speed for the "stern-frame" specials never exceeding five miles per hour.

The great weight and size of the various castings for one of these new White Star steamships put out of question their erection preparatory to leaving the Darlington Forge Company's works, and therefore it is not possible to include



LOWER PORTION OF STERN FRAME OF OLYMPIC

illustrations of the stern frame, brackets, and rudder complete, but the accompanying engravings afford a good idea of the design and dimensions of the various pieces.

DOCKYARD NOTES.

ACCORDING to the French newspapers, which very often nowadays know more about these things than we do over here, the Blanche will carry ten 4in. guns and the Newcastle two 6in. and four 4in. The latter statement, however, strikes us as doubtful.

THE maximum speed reached by the German cruiser Blucher on her trials was 25.33. This is a great deal in excess of what she was designed for.

A UNITED STATES Congressman by the name of Roberts is heading an agitation against the two 25,000-ton battleships which it is proposed to build. He wishes to see constructed instead one monster 30,000-ton battleship, carrying twelve 14in. guns, which he declares would be more than equal to the two 25,000-ton ships. In a certain sense this is perhaps so. On the other hand, the 30,000-ton ship could only be in one place at once! Incidentally, also, there is probably no dock that would be able to take it if built. It might furthermore be advanced that one ship of 40,000 tons would be superior to two of 30,000, and so on *ad infinitum*.

THE first of the new Spanish battleships has been laid down at Ferrol; she will be named Espana.

THE new Greek warship now turns out to be the cruiser which was building in Italy on chance of sale. She will be named Averof. The armament consists of four 10in. and eight 8in. guns. She is in every respect a sister to the Italian Pisa.

THE reported breakdown of the St. Vincent on her trials was a very small affair, and merely amounted to a mishap to one of the auxiliary pumping engines, and even that of a minor nature.

A GOOD many interesting stories are going round as to the armament of H.M.S. Lion, including the report that Admiral Sir John Fisher had designed the arrangement of guns! For this, so far as we can ascertain, there is absolutely no truth whatever. The present trend of British naval architecture is towards having all guns on the centre line, but the invention, or rather the resuscitation of this idea comes from America,

RADIO-TELEGRAPHIC APPARATUS AT THE ARMSTRONG COLLEGE

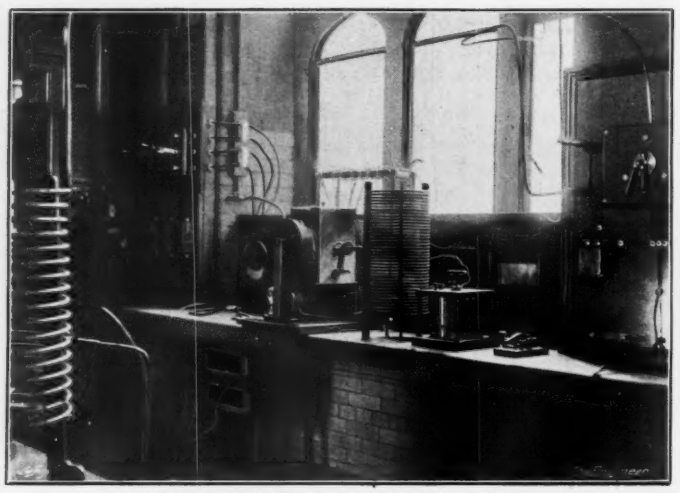


Fig. 1—POULSEN ARC SENDER

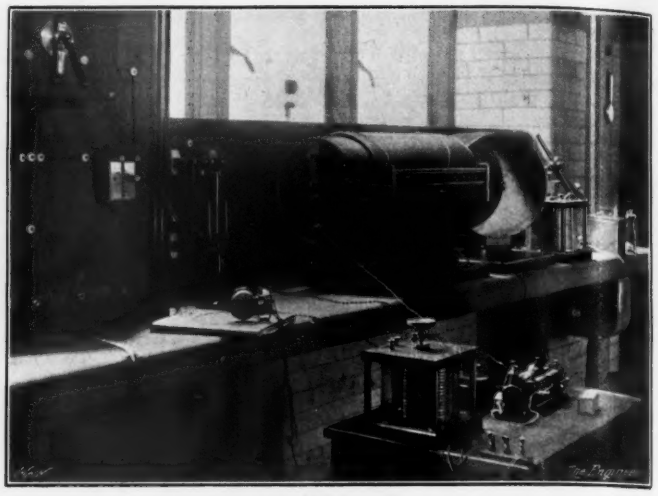


Fig. 2—THE RECEIVING SIDE

In the early sixties this arrangement appeared in the British Navy, in the turret ships Royal Sovereign and Prince Albert. There is, therefore, nothing left for anybody to invent in this direction to-day.

THE ARMSTRONG COLLEGE RADIO-TELEGRAPHIC STATION.

IN the course of his presidential address at the opening meeting of the present session of the Newcastle-on-Tyne section of the Institution of Electrical Engineers, which was held on the 22nd of October, Professor Henry Stroud described the radio-telegraphic station in the Physical Department of the Armstrong College, which has recently been licensed by the Postmaster-General for experimental purposes. The towers of the College permitted the use of a very simple method of erecting the antenna. In its construction about 1500ft. of wire cable are used; the cable is seven-stranded, and is made up of No. 20 S.W.G. bare silicium bronze wire. A double cable of this wire, about 170ft. long between the insulators, is stretched between the Sir Lowthian Bell tower (130ft. high) and the Jubilee Exhibition tower (80ft. high). The double cable is insulated at each end by three porcelain insulators of special construction so as to prevent the ends of the wire falling in case of the breakage of the insulators. Two sets of cables of the same wire are attached to the 170ft. of insulated double cable, and lead to the room where the signals are sent and received —one set consists of five cables suitably spaced towards the higher tower end, the other set comprises three cables suitably spaced towards the lower tower end. The King's Hall

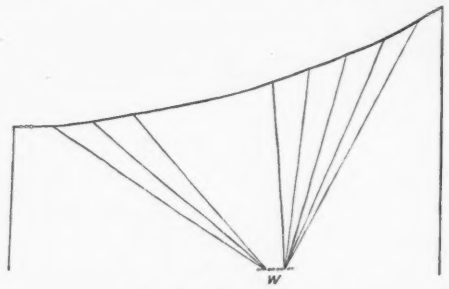


Fig. 3—THE ANTENNA

necessitated this division into two sets; but it is arranged, by separately insulating the two sets, that the antenna can be used as a "loop" antenna, or all the eight cables can be joined at their lower ends, thus forming a "fan" antenna, but of unsymmetrical type. The connections between the insulated antenna and the experimental room are made through two leading-in tubes of porcelain above one window. Each porcelain tube, which is filled with paraffin, has a brass tube, furnished with terminals at the ends, along its axis. The lower ends of the two sets of the antenna cables are joined to the outer terminals on these brass tubes, the inner terminals being normally joined together, and connected to the switch in the centre of the wall of the room. The antenna is thus in the normal connection a "fan" antenna. The centre switch enables the antenna to be joined to (1) the spark sender, (2) the Poulsen arc sender, (3) the earth, (4) the receiving side. The earthing wire, used for sending and receiving, is a thick cable proceeding through the floor out to an extended lead roof over a corridor.

The spark sender consists of an 18in. Apps' induction coil, which can be excited from the city alternating supply—100 volts—through a resistance, or, using a mercury or other break, by means of storage cells up to 100 volts. The sending circuit includes a battery of large Leyden jars arranged in parallel and series. This condenser discharges through an inductance consisting of a few turns of a helix of stout copper tubing and various types of spark gap. The capacity and inductance are adjusted for a wave length of 600 m. At present the coupling with the antenna circuit is direct, as it is usually in the Braun sender. Such a number of turns of the helix is included in the antenna circuit as to produce the correct wave length.

The Poulsen arc generator is of an experimental type, having a separately excited magnetic field which can be varied over a wide range. The arc is struck between the usual copper and carbon electrodes inside a closed chamber with marble sides, with means for admitting hydrogen, coal gas, &c. A suitable atmosphere can also be provided by means of a spirit dropper, which allows alcohol to drop on to the copper electrode, or into the arc near the copper. The arc is fed from the city direct-current 240 or 480-volt mains through regulating resistances, air cored choking coils being introduced to prevent the oscillations passing to the supply mains. Under normal working conditions one terminal of the arc is connected to earth through a large capacity—block condenser—the other terminal being connected through a similar condenser to an inductance and capacity which are connected to the antenna. The capacity, which is in parallel with the inductance, is an oil condenser, and both it and the inductance can be changed to give various wave lengths up to 1500 m. The sending key is arranged to short-circuit either an extra capacity or an extra inductance in the antenna

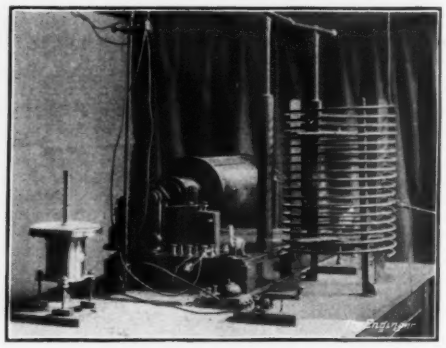


Fig. 4—SPARK SENDER

circuit, so as to produce the variations in wave lengths by means of which signalling is effected on the Poulsen system.

For the receiving circuit, a primary coil, wound with No. 14 wire over an ebonite cylinder (12in. diameter), is arranged with its axis horizontal. Spring contacts connect the turns of the coil in use to the antenna and to earth, a variable condenser being arranged in parallel with the coil. By means of a double-pole change-over switch, the variable condenser can in a moment be changed from the above connection and put in series with the coil between the coil and earth. In this way the wave length can be adjusted between wide limits from the lowest wave length used in wireless telegraphy of about 300 m. up to the highest used by Marconi of nearly 4000 m. Inductively coupled with this coil is another coil, sliding within it, also wound on an ebonite cylinder but of slightly smaller diameter. To this secondary, which can be closely or loosely coupled to the primary by sliding it in or out along guides, are connected the various detectors, electrolytic, thermoelectric, &c. Near one end of the primary coil is arranged another secondary wound on an ebonite cylinder (13in. diameter), with a finely stranded conductor consisting of 21 strands of No. 35 silk-covered wire. This secondary is intended for use as the receiving circuit for the undamped Poulsen waves. Variable condensers are joined to the turns of this secondary coil, and adjustment of the wave length is made by means of contacts on the secondary and the variable capacity. By means of a Poulsen "tikker" the energy, accumulated by resonance, intermittently charges a condenser across which is the receiving telephone. The coupling between the tuned primary and secondary of the Poulsen receiver is varied by the rotation about a vertical axis of the secondary before one end of the primary coil, whose axis is horizontal.

The diagram reproduced in Fig. 3 shows the wire arrangements for the fan-shaped antenna. The vertical lines at the sides indicate the positions of the two high College towers. A double cable of bare wire is stretched across between the towers (80ft. and 130ft. high). The insulators at each end are indicated by the small circles. Bare wires in two sets converge from the double cable to the experimental room (marked W) in the physical department. The two sets of wires can be connected together at their lower ends, thus forming the fan antenna. Fig. 4 illustrates the spark sender in the centre of the experimental room. The large induction coil is seen, together with the helix of copper tube. The Leyden jars are beneath the table, the spark gap is behind the helix. The sending key is in front. In Fig. 1 is shown the Poulsen arc sender. Behind the left end of the table are the supply switches for the arc and electro-magnet, to the right of which is the Poulsen arc (experimental type) with the helix and variable condenser for the oscillation circuit. To the extreme right is the antenna-connecting switch. The antenna-connecting wires come through tubes above one window. The helix to the extreme left belongs to the spark sender. Fig. 2 shows the receiving side. The antenna-connecting switch is at the top left-hand corner. In the position shown the central terminal, joined to the antenna, is connected by the switch to the bottom stud, which is joined to earth by means of the wire passing over the edge of the table. The stud to the left connects to the Poulsen arc sender, one at the top—shown in Fig. 1—to the spark sender, and that to the right to the receiving side. The ordinary receiving coils are seen on the table with a tuning condenser on a small table in front, on which are the detectors. The receiving telephone is lying on the wall table. On the extreme right are the Poulsen receiving arrangements.

We understand that communications have passed very successfully between the Cullercoats wireless station and the Armstrong College, and, moreover, that messages have been received over a very wide range. The Armstrong College wireless station is under the direction of Professor Stroud and of Mr. Morris-Airey, who have had the benefit of the technical advice of Mr. A. Sörensen, the engineer and manager of the Cullercoats radio-telegraphic station.

TURBINE *v.* PISTON ENGINES IN WARSHIPS.

THE two most recent additions to the United States navy, the Dreadnoughts Delaware and North Dakota, have recently carried out important steam trials, with the results set forth in the accompanying table, which has been sent to us as official. We have commented at some length on these figures in our leader pages. The Delaware has reciprocating and the North Dakota turbine engines.

DELAWARE.

Water per indicated horse-power per hour, main engines only	12 knots, 15·48 lb.	19 knots, 12·7 lb.	21 knots speed, 12·9 lb. water
Water per indicated horse-power per hour, all purposes	12·24 knots, 21·03 lb.	19·225 knots, 14·52 lb.	21·563 knots speed, 14·8 lb. water
Total water per hour, all purposes	12·24 knots, 83,463 lb.	19·225 knots, 250,549 lb.	21·563 knots speed, 422,931 lb. water
Total water per hour for main engines only	12 knots, 55,000 lb.	19 knots, 205,000 lb.	21 knots speed, 312,000 lb. water

NORTH DAKOTA.

Water per shaft horse-power per hour, main turbines only	12 knots, 20·6 lb.	19 knots, 14·25 lb.	21 knots speed, 13·8 lb. water
Water per shaft horse-power per hour, main turbines and engines' auxiliaries...	12·1 knots, 23·94 lb.	19·245 knots, 15·92 lb.	21·64 knots speed, 14·408 lb. water
Total water per hour, main turbines and engines' auxiliaries	12·066 knots, 90,984 lb.	19·245 knots, 256,761·1 lb.	21·64 knots speed, 450,965 lb. water
Total water per hour for main turbines only	12 knots, 76,000 lb.	19 knots, 23,800 lb.	21 knots speed, 349,000 lb. water

RAILWAY MATTERS.

MATERIALS for the electric tramways in Dairen are being obtained from various countries, the rails and cars coming from the United Kingdom. The total length of the system will be 13 miles.

THE Adelaide correspondent of *The Standard* cables that the South Australian Parliament has sanctioned the construction of 300 miles of railway line, which will open up over 3,000,000 acres of magnificent arable land.

THE Board of Trade have recently confirmed the undermentioned Order made by the Light Railway Commissioners:—Mid Suffolk Light Railway (Amendment) Order, 1909, amending the Mid Suffolk Light Railway Orders of 1900, of 1903, and of 1905.

A RETURN recently issued shows that in no less than five instances where local authorities or companies sought parliamentary consent to tramway schemes, while the general schemes were sanctioned, the clauses seeking powers to adopt the trackless trolley system were struck out.

ACCORDING to the *Railway News*, the London and North-Western Company's projected new loop line at Coventry is estimated to cost under £200,000, and not £2,000,0 0, as had been rumoured. This line is intended to afford connection with the Nuneaton branch railway, serving various collieries, and also with the main line to London.

THE Philadelphia Rapid Transit Company reports that on certain of its lines in that city since the introduction of "pay-within" street cars, the number of accidents to persons has decreased 74 per cent. This remarkable change is attributed to the arrangement of closed doors and steps, making it impossible for passengers to get on or off when the cars are moving.

IMPORTANT developments are discussed in connection with railway enterprise in Japan. The Canadian Trade Commissioner at Yokohama states, in a recent report, that a sum of about £4,000,000 is to be appropriated in the next Japanese Budget for the erection of a central railway station at Tokio, for laying two more tracks between Tokio and Yokohama, and for replacing the rails over a large part of the railway system by heavier ones. The Commissioner remarks that it will be impossible to obtain any order in connection with the above-mentioned work except through a representative on the spot.

THERE are over 400 miles of railway now in operation in Guatemala, and various extensions are in prospect. One of these contemplates the building of a line from Zacapa on the Northern Railroad, about 100 miles from the sea, to Santa Ana, on the north-western frontier of Salvador, where it will connect with the British railway already built, and thereby with the capital of Salvador. Much of the coffee now grown in that Republic will thus find an outlet to the Atlantic of which it has long been in need, and it is highly probable that the bulk of the import trade to Salvador will also be conducted along this route.

THE first sod of the Ichang Chengtu section of the Hankau-Szechuan Railway was cut on December 13th. The occasion gave rise to a demonstration of patriotic Chinese feeling. This section of the line was allotted by Prince Ching to British construction in the event of foreign capital being required. The British, French, German, and American financial groups interested have not yet come to an agreement with regard to the financing of the line. The Chinese provincial authorities and gentry now refuse to allow the foreign construction of this section, and have raised funds with a view to building the line themselves.

THE gross receipts of Russian railways in 1908, exclusive of the Grand Duchy of Finland, amounted to R. 789,406,338—£83,314,645—as compared with R. 796,459,036—£84,058,995—in the preceding year, showing a decrease of no less than R. 7,052,698 - £744,350. The diminution in the earnings is attributable almost wholly to a failure of the harvest, in consequence of which a smaller quantity of grain was carried out of the country by rail. In 1908 only 285,328,500 pouds—4,599,274 tons—of grain of all kinds were despatched by the railways, while the quantity of this commodity so transported in the previous year amounted to 302,198,250 pouds—4,871,836 tons—or a decrease of 16,869,750 pouds—272,562 tons.

THE formal opening and linking-up of the British and Congolese sections of the Cape to Cairo Railway took place on Saturday, December 11th. The section of the Rhodesia-Katanga Railway, covering 131 miles from Broken Hill to the border, opened on December 11th, was commenced on July 1st. At present eight miles have been built on the Belgian section, which extends 160 miles from the border to the Star of the Congo, the greatest mine in Katanga. Thence it will be continued to Kambowe, and ultimately it will doubtless be connected with Bunguella, but it is understood this portion of the line will not be completed for several years. Pending that development, oversea traffic with the newly-opened territory will pass through Beira.

ON November 1st, the United Railways and Electric Company, of Baltimore, Md., put into use a system of oiling the motor bearings of all revenue cars on a mileage basis. Motors are oiled at the division car houses on instructions from the office of the superintendent of shops, where all records of mileage are computed. Mail, express, maintenance of way, and special parlour cars are not included in the plan, nor are snow-ploughs and sweepers. The system is not intended to supplant the previous practice of having car-house foremen follow closely the mileage of the cars in their charge, but it is believed it will relieve those divisions where the work of computing the mileage daily has proved too great a task, and will result in better economy and efficiency of lubrication on the whole system.

WE hear that the Kirkcaldy and Dysart Town Council have now agreed on terms for the extension of the Kirkcaldy tramways to Dysart. By the agreement the Kirkcaldy Corporation undertakes to construct a single-line tramway with three or four passing places along Dysart-road from the junction with their existing tramways to a point in Normand-road, about 80ft. east of the centre of the East Port, Dysart, and on the completion of the construction of the tramway to run a suitable service of cars between Junction-road, Kirkcaldy, and the Dysart terminus. The Kirkcaldy Corporation will maintain a portion of the road in connection with the tramway track, and the Dysart Corporation will in return pay to Kirkcaldy £150 annually for ten years. A Provisional Order has been applied for, and it is proposed to proceed with the extension early next year.

ON the 31st December, 1908, the Assam-Bengal Railway Company had 86 locomotive engines out of 95 fitted with the vacuum automatic brake; also the whole of its coaching stock, namely, 266 vehicles braked and 7 vehicles piped. A fair proportion of the goods stock was also fitted, namely, 560 vehicles were braked, 131 vehicles piped, and 1637 vehicles were not fitted. The ruling gradient between Chittagong and Badarpur Junction, forming the Southern Section, is 1 in 150; and on the Hill Section—Badapur-Lumding—1 in 60. On the Gauhati-Tinsukia Northern Section the gradient is 1 in 100, and it is still easier on the Noakhali, Chandpur, and Silchar branches, namely, 1 in 200, 1 in 300, and 1 in 150 respectively. During next year the company intends to make the following additions to its rolling stock:—Ten third-class bogie carriages, 6 passenger brake vans, 4 horse-boxes, and 50 high-sided goods wagons. It is also proposed to fit 200 more iron covered goods wagons with the vacuum automatic brake.

NOTES AND MEMORANDA.

THE production of mercury at the Almaden mines, Spain, was 1,017,023 kilos., or 29,472 flasks in 1908. At Micares it was 50,685 kilos.

VARIOUS experimenters have recently endeavoured to determine the exact distribution of the magnetic lines of flux in the air-gaps of dynamos by means of testing coils. The author of a paper read in America points out that these methods give only approximate values, because the testing coils must have certain dimensions, and therefore give only the mean of the fluxes within the space covered. The author shows how to apply a correction to change the curve which is experimentally plotted into a curve which represents more correctly the exact distribution of the flux.

DR. H. S. HELE SHAW recently delivered a lecture to the members of the Edinburgh Philosophical Institution in the U.F. Assembly Hall on "Aerial Navigation." With the assistance of a series of lime-light views, he described the evolution of aerial navigation, and compared the balloons with the heavier-than-air machine. He remarked on the effects of the aerial currents on navigation, and said that he did not think a passenger dirrigible balloon would be a success, owing to the cost of upkeep and the small number of passengers it would be able to carry. The three essentials of airships were power, stability, and the power of direct movement through the air.

IN a patent recently issued to Dr. C. P. Steinmetz, a description is given of a machine having interpoles without winding which operates sparklessly. The armature of the machine is of the closed-coil type provided with both a commutator and collector rings. The arrangement for operation is such that the m.m.f. of the current entering by way of the collector rings is greater than that leaving by way of the commutator, and the excess m.m.f. serves for exciting the interpoles to the extent required for sparkless operation. This result is obtained when the machine receives all of its power over the collector rings, and delivers only a part over the commutator, the remainder being utilised mechanically at the pulley.

AS a result of the experiment made by the Sydney City Council in street lighting with metal-filament lamps, in place of the existing arc lamps, the electrical engineer has come to the conclusion that while there may be better illumination of the side walks, it would be impossible, without adding greatly to the cost of lighting, to get the brilliant effect necessary in the main thoroughfares of the city by means of incandescent electric lamps. For these places he thinks the existing type of open arc lamps should be exchanged for flame arcs at a cost of £3000, and in future extensions of the lighting system streets that are too narrow and too crooked to get the full benefit of the light from arc lamps should be illuminated by metal-filament lamps.

BY microphotographic methods, the vibrations in an incandescent filament, due to the expansion and contraction caused by the passage of an alternate current, have been recorded. An arc lamp was used as the source of light for photographic purposes, and if the arc is fed from the same alternator as the incandescent filament, the vibrations are seen from the plate to synchronise with the rise and fall of the alternating pressure With a 100 candle-power osram lamp, supplied with alternate current at 50 alternations, a slight humming noise was perceptible even at a distance of three yards, but this is not usually noticeable in a lamp mounted in a vacuum. The experimenter considers that this may be a cause contributing to the shorter life of a metallic filament on alternate current.

A NEW method of bonding new concrete to old was described by Mr. Frank Barber, of Toronto, in a recent article in the *Canadian Engineer*. This consists in placing bags of cracked ice on the last surfaces of concrete placed at night, thus reducing the temperature of the concrete, and, consequently, retarding its time of setting, so that on the next morning the surface is still plastic, and the concrete then placed will set in one mass with the old. The invention of this scheme is credited to Mr O L Hicks, when he was contractor for a reinforced-concrete truss bridge in Ontario. As all of the members in these trusses were of relatively small cross section, the ice bags were easily placed in position, at the end of a day's work, and it is stated that the method worked very successfully. To what extent it could be applied to heavier work is not as yet known.

A CONSIDERATION of the mechanical principles involved in valve construction, and the duty required lead to the conclusion, says an American contemporary, that electrically operated stop valves offer many advantages, as compared with the hand-operated type. They can be operated from any point, often permit a simpler layout of piping, and, in time of accident, make it possible to shut off a valve that might otherwise be inaccessible on account of fire, escape of steam, &c. The stopping and starting of large units upon short notice is expedited by motor-driven valves for the large exhaust piping, and when installed between the boilers and steam header, or the header and the engine, and between sections of the leader, they enable any break in the piping to be isolated at once, or any other trouble checked by closing switches which may be situated a safe distance away from the piping.

A PAPER dealing with "Research on Metallic Filament Lamps," by Mr. F. H. Reakes Lavender, was recently presented at a meeting of the Birmingham Institution of Electrical Engineers. The research was undertaken in order to investigate the conditions of working as regards voltage, and efficiency and percentage drop in candle-power, giving the most economical life in the case of metallic filament glow lamps, and to determine as far as possible the cost of illumination with this source of light. The author stated that the useful life of a lamp, and the drop in candle-power which it was advisable to allow for a given voltage, depended on the cost of current and the price of the lamp. The cheaper the current, the longer the life, and the greater the admissible drop. Taking the current at 5d. per unit as an average price, and the lamp run at rated voltage, then it paid in the case of the Tantallum class of lamp to throw it away as soon as the candle-power had fallen to 3 per cent. below its original value. This result appeared startling at first, considering the large initial cost of the lamp. However, by the time that point was reached the lamp had been burning for 1500 hours at the best possible efficiency, so that the cost of the lamp per candle-hour had become small.

IN a paper on "The Mechanics of Dust," read before the Society of Engineers by Mr. C. H. W. Biggs, the author says "one of the most interesting investigations, and one open to every student, is that of the effect of minute air currents upon dust particles. Imagine for a moment dust particles having very large surface compared with their mass. Fortunately, the student can on occasion easily see such particles, and watch their evolutions, in a room where otherwise it is almost, if not quite, impossible to detect air currents by other means. Smoke consists of small particles of matter, and is in daily use to detect minute currents of air both in drains and in rooms. There is an excellent way to investigate and to follow the motion even of individual particles. Dr. Travis, in his experimental work on seeing colloidal matter, makes great use of the ultra-microscope. You can get something of this effect in rooms where a window faces a bright sun. Darken the room, leaving only a hole—preferably circular—through which to get a beam of bright sunshine. Thus we get a cone of brilliant light through the room. In this cone you can see dust particles playing all manner of antics, some falling, some rising, some going in one direction, some in another, the direction of the small masses being the direction of the resultant of the forces acting."

MISCELLANEA.

THE Belgian Consul in Central America reports that vigorous efforts are at present being made to introduce modern methods and machinery into the agricultural industry in that Republic.

A MOSCOW Consul recently reported: "Electrical engineers have chances to exploit their ability in the Baku district, as electrical power is being instituted in the immense oil fields of that district. Oil well supplies, such as casing, drilling tools, rig and engineering machinery, and irrigation outfits are in demand."

ON Tuesday last, the Chinese Minister in Paris took formal possession of the standards of weights and measures which the Chinese Government ordered last spring from the International Office of Weights and Measures in the French capital, for the purpose of introducing the metric system in China, in conformity with the law promulgated in 1908.

IN an American Consular report it is stated that a company in British Columbia is working an electric process for the distillation of turpentine from mill refuse, tree stumps, &c. Six or eight gallons are obtained from a cord of wood, and the product is said to be chemically pure. The cost of erecting a mill is estimated at £300 "per cord to be treated." The by-products find a ready sale.

THE French Deputies were presented a few days ago with specimens of the new aluminium coinage with which it is proposed to replace the bronze coins in France. The 10 centimes piece is described as "something between a counter and a trouser button," and is said to be even less attractive in appearance than a nickel coin, and to be "ugly and unbandy." The "sou" is much the same, but, of course, rather smaller, and it is expected that both, if they are adopted, will cause considerable confusion.

IT is announced by the Cunard Company that commencing with the New Year, and during the remainder of the winter season, their vessels from New York will steam direct to Fishguard, omitting the call at Queenstown. Since the starting of the quicker service from New York to this country, *viâ* Fishguard, more than 2000 passengers have made use of the facilities provided, and they have, without exception, expressed themselves in terms of appreciation of the advantages derived and the saving of time effected.

A CONSULAR report dealing with the trade of the consular district of St. Petersburg states that it is gratifying to see that the import of machinery from the United Kingdom increases year by year. The high figure for 1908 has never been reached before, and shows an additional quantity of over 100,000 poods compared with 1907. Germany also benefited by the increased demand, but the percentage of its share in the general import of machinery during the year under review was considerably less than that of the United Kingdom, viz., 21.2 per cent. against 72.8 per cent.

THE Council of the Sheffield Chamber of Commerce met at the Cutlers' Hall on Monday last. Mr. James Boyd Adams, of the Labour Exchanges Department of the Board of Trade, conferred with the Council as to the founding of the new Government Labour Exchange in Sheffield. He explained what it is hoped to do with the Exchange, and his views were listened to sympathetically. It was felt that the employers of Sheffield ought to do their best to give the scheme a good start in the city. Premises are to be taken in Suffolk-road as the headquarters of the Labour Exchange in Sheffield.

IN his presidential address to the Chartered Institute of Patent Agents, Mr. O. Imray dealt with the results of section 27 of the Patents and Designs Act, 1907. It had been reported, he said, that in one year's working eleven patents had been revoked by consent, and four after a contest. Only one patent had been revoked at the instance of a British manufacturer anxious to manufacture the patented article. The section had, however, resulted in the introduction into this country of several industries by foreigners owning British patents. He suggested that the Act should be altered so that manufacture in one country of the Patents Union should protect a patentee from the revocation of his patent in all countries of the Union.

THE central station on the moors in East Friesland, states the *Electrical Review*, was opened for public supply on November 15th. Peat is used as fuel, and it is calculated that the quantity available is sufficient to raise steam for a period of 100 years. The cost of establishment has amounted to £150,000, the plant is capable of dealing with a demand for 5,000,000 kilowatt-hours per annum, and the distributing network extends over 150 miles. Various contracts for supply to local authorities have been concluded, but the dockyard at Wilhelmshaven is not connected with the mains, as the erection of two plants for dock and lock works was projected before the station was built, and has already been carried partly into effect. On the other hand, the station affords a supply to the harbour works at Emden. It is expected that the contemplated tramways at Wilhelmshaven and Rustringen will be operated from the moorland station.

A CONFERENCE to discuss the needs of technical education in Burma was held at Rangoon early in November. Mr. J. G. Coverton, Director of Public Instruction, in opening the discussion, presented a brief sketch of what had been done in the past in the way of technical education. He divided the work of technical instruction into two main groups:—(1) Those connected with scientific professions, especially engineering; (2) those connected with ordinary country and home life. He proposed that a central technical school for industrial education in the vernacular should eventually be opened at Insein in connection with the engineering school, and related to all the selected vernacular schools for technical education which may hereafter be established, and that pupils who showed special aptitude for technical training should be drafted to this central school. The instruction should be in the vernacular, and its aim be to provide for a general technical training for hand and eye. For trained pupils who might hope to be skilled artisans in various crafts and industries there should, the director said, be local industrial schools.

ACCORDING to a contemporary, some interesting tests have recently been carried out by Messrs. Kirkaldy and Son for H.M. Office of Works on some reinforced concrete columns in connection with the new General Post-office. The columns were twelve in number, and measured 9in. square by 6ft. in length, and were tested under thrust. The concrete used was composed of one yard screened Thames ballast, crushed to pass $\frac{3}{4}$in. mesh, half yard Thames sand, and 6 cwt. Portland cement, all machine mixed fairly dry. The age of the columns was from two and a-half to three months. The reinforcement consisted of four 1in. steel bars spaced 5in. centres, and tied by $\frac{3}{16}$in. wire links at intervals varying in the different specimens, except in two columns, the tying of which was accomplished by the use of expanded metal of 1$\frac{1}{2}$in. mesh and $\frac{3}{4}$in. by $\frac{1}{8}$in. strand, the slits running longitudinally. Two exactly similar columns of each type were tested, in order to secure trustworthy results. The ends of the columns were trued up before testing, and the depression was measured after each increment of load of 20,000 lb. Failure occurred in all the columns in the same way, namely, by crushing at a point from 1ft. to 2ft. from the upper end, the concrete cracking away and exposing the reinforcement. The ultimate load varied from 85.2 to 107.5 tons, according to the distance apart of the binding ties, the highest results being obtained when the wires were 6$\frac{1}{2}$in. apart throughout the greater part of the length, and 3in. apart near the ends. The two columns with expanded metal binding failed at 73.1 and 76 tons, owing to spreading of the mesh.

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(For description see page 633)

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H.M.S. VANGUARD.

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CONTENTS.

THE ENGINEER, 17th December, 1909. PAGE

NOTES ON THE DESIGN OF SHAFTS, WITH SPECIAL REFERENCE TO HIGH-SPEED ELECTRIC GENERATORS 623
SOME RECOLLECTIONS OF SOHO FOUNDRY, ITS MEN AND METHODS. (Ill.) 624
LITERATURE 627
LOCOMOTIVE PROPORTIONS AND POWER 628
MARCONI WIRELESS TELEGRAPHY. (Illustrated.) 630
THE LUBRICATION OF CHECK RAILS. (Illustrated.) 632
STERN FRAMES AND BRACKETS OF THE NEW WHITE STAR LINERS. (Ill.) 632
DOCKYARD NOTES 633
THE ARMSTRONG COLLEGE RADIO-TELEGRAPHIC STATION. (Illustrated.) 634
TURBINE *v.* PISTON ENGINES IN WARSHIPS 634
RAILWAY MATTERS 635
NOTES AND MEMORANDA 635
MISCELLANEA 635
LEADING ARTICLES—Compound Locomotives on the Midland Railway .. 637
A Copper Trade Combination—Turbines in the United States Navy 638
The New French Dreadnoughts 639
OBITUARY 639
DIRIGIBLES AND AEROPLANES FOR THE FRENCH ARMY 639
VERTICAL COMPOUND CORLISS ENGINE. (Illustrated.) 640
A NEW PARTITION SLAB 640
NEW STEAMSHIPS FOR THE GRAND TRUNK PACIFIC RAILWAY COMPANY .. 641
BORING AND TURNING MILL WITH DRILLING ATTACHMENT. (Illus.) .. 641
LAGOS AGRICULTURAL SHOW, 1910 640
MOTOR RAILWAY SERVICE, LONDON, BRIGHTON AND SOUTH COAST RAILWAY. (Illustrated.) 642
EXAMINATION OF MARINE ENGINEERS 642
A NEW ELECTRICAL TOWER CRANE. (Illustrated.) 643
LETTERS TO THE EDITOR 643
REPAIRING A ROLL MILL HOUSING. (Illustrated.) 644
DRESSING GRINDSTONES. (Illustrated.) 644
THE FERRY STEAMER GUANABACOA. (Illustrated.) 645
ROLLER BEARINGS FOR ROAD MOTORS. (Illustrated.) 645
MANCHESTER ASSOCIATION OF ENGINEERS 645
SUCTION GAS ENGINE. (Illustrated.) 646
SHOP TESTING OF DIRECT AND ALTERNATING-CURRENT MACHINERY 646
THE INSTITUTION OF CIVIL ENGINEERS 648
LETTERS FROM THE PROVINCES, &c. 648
BRITISH PATENT SPECIFICATIONS. (Illustrated.) 651
SELECTED AMERICAN SPECIFICATIONS. (Illustrated.) 652

TO CORRESPONDENTS.

☛ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☛ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☛ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

INQUIRIES.

COATING IRON OR STEEL WITH LEAD.

SIR,—Can any of your readers tell me of any process for covering cast iron or steel with lead, so that the articles so formed are acid proof, and can be used in acid solutions? C. W.
December 14th.

MEETINGS NEXT WEEK.

ROYAL SOCIETY OF ARTS.—Monday, December 20th, at 8 p.m., at John-street, Adelphi, London, W.C. Cantor Lecture: "Aeronautics," by Charles Cyril Turner.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, December 21st, at 8 p.m., in the Lecture Hall of the Institution, Elmbank-crescent, Glasgow. General meeting. Paper, "Concrete Pile Foundations, with Particular Reference to the 'Simplex' Method of Constructing Same," by Mr. Alexander Melville.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 21st, at 8 p.m., at Great George-street, Westminster, S.W. Ordinary meeting. Discussion, "Railway Signalling in India," by Charles William Hodson, C.S.I., M. Inst. C.E. Paper, "The Design of Rolling Stock for Smooth Rail Working on Heavy Gradients," by Frederick William Bach, M. Inst. C.E.

THE INSTITUTION OF MECHANICAL ENGINEERS.—This evening, Friday, December 17th, at 8 p.m., in the Institution House, Storey's Gate, St. James's Park, Westminster, S.W. Ordinary general meeting. Papers: "Mild Steel Tubes in Compression and under Combined Stress," by Mr. William Mason. "Compound Stress Experiments," by Mr. C. A. M. Smith, B.Sc.

THE ENGINEER.

DECEMBER 17, 1909.

Compound Locomotives on the Midland Railway

IT is not easy to overestimate the value of Mr. Deeley's contribution to the literature of the locomotive, which will be found on another page. It will be remembered that we recently called attention to the fact that only those in authority in the locomotive department of British railways were familiar with the hidden life of the engines which work the traffic of our greater lines of intercommunication. Mr. Deeley was for years intimately acquainted with the working of the Midland Railway, of which he has been chief mechanical engineer for a considerable period. He is full of minute information. He understands exactly what he is writing about; and he gives quite freely his experience of the compound locomotive as tried on the Midland Railway. It will be seen that he begins by admitting that the compound system has been tried and failed, and is unpopular in this country. He attributes this to want of power to deal with heavy trains; but he does not say in what respect power was lacking, save in capacity to start such trains. Seeing that the "John Hick" class of Webb compounds had two 15in. high-pressure and one 30in. low-pressure cylinders, all 24in. stroke, with 6ft. 3in. wheels, we have, on paper at all events, a very powerful engine. The Midland compounds are quite different in type. Mr. Deeley has so fully explained their peculiarities that it would be superfluous to describe them here, particularly as they were illustrated in our pages in March, 1906. We have the Webb system reversed. But the most important fact is that Mr. Smith got rid of all the complicated forms of reducing valves, and took high-pressure steam direct into the low-pressure cylinders for the purpose of starting his trains. The low-pressure cylinders are 21in. diameter, with an area of 346 square inches. The pressure in the boiler is 220 lb., and when starting it is certain that the cylinder pressure will be at least 200 lb. Now $200 \times 346 = 69{,}200$ lb., or a little over 30 tons. A very heavy stress which, however, we gather, is borne with equanimity by the machinery. The steam goes direct from the boiler through a pipe only 2in. in diameter; but a pipe ½in. in diameter would suffice, while the piston was not moving, or moving very slowly, to give a cylinder pressure identical with that in the boiler. Leaving out the effect of the steam in the high-pressure cylinder for the moment, because of the relief valves, which we gather place the piston in equilibrium, we have by the usual formula a draw-bar pull of 126 lb. per pound of average pressure in the cylinder, and $126 \times 200 = 25{,}200$ lb., or in round numbers, 11 tons, which is about twice as much as the adhesion would suffice to utilise. It is clear, therefore, that the Midland compounds must be competent to start with ease the heaviest train that they can be called upon to pull, and so one defect of the compound system is absent.

The special value of Mr. Deeley's article will become manifest if we compare it with one written by "A Fireman," and published in our impression for August 20th. It will be seen that the experience of "A Fireman" shows a saving in coal consumption of over 20 per cent. No doubt the figures he gave are quite accurate, but they apply only to certain trains, loads, and speeds. Mr. Deeley, with the whole group of forty-five compounds before him, gives the saving in coal as not more than 7½ per cent. It is quite useless to argue that if this or that had been done with the engines better work would have been accomplished. Here we have the results of an experiment carried out on a great scale by a man who firmly believes in the compound system, and wishes it to be a success. Yet the utmost he can claim is little when compared with the assertions made on the Continent. A small difference in the quality of the coal, in the ability of the drivers and firemen, in the cleanliness of the boilers might easily account for more than this percentage. Unfortunately, too, the differences between the compound and the simple engines are in many respects radical; so great, indeed, that it is impossible to make a simple comparison based on compound *v.* simple alone. The comparison lies between two types radically diverse on points of an extreme importance—an importance which is seldom rated at its real value. Mr. Deeley explains that a great advantage is gained by sub-dividing the work among three cylinders instead of two. Compensation is much simplified, and the turning moments are equalised. We would direct particular attention to what Mr. Deeley says concerning the heating of long bearings under the heavy stress of large pistons and high pressures. Let us suppose for a moment that the engine was of the non-compound three-cylinder type—first patented by Stephenson, if we are not mistaken—is it not certain that it would possess many of the advantages claimed—and properly claimed—for the Midland compounds? Compounding is an addition, a something thrown in, and no doubt useful and worth having. But we must not shut our eyes to the fact that in many ways a three-cylinder locomotive will, in any case, be better than one with two cylinders when great power is demanded to draw such trains as are now run at very high speeds over long non-stop distances. Three 16in. cylinders are no doubt better than two 19½in. as regards stresses and compensation and balancing and equalisation of turning moments.

Again, it is only too easy to undervalue the good gifts which high pressure confers on the locomotive superintendent. Two hundred and twenty pounds is an heroic pressure. "The higher pressure put in the later engines was," says Mr. Deeley, "to give a reserve of steam on heavy banks, rather than to secure economy." The first thing to be secured is that the engines shall keep time; after that try for economy. It is clear that at every step Mr. Deeley has aimed at turning out an engine which will meet the greatest demands that a traffic manager can make on it; and it is quite open to those who do not believe in compounding to say that he has done this in spite of the fact that his is a compound locomotive. The high pressure which he uses could, of course, be used in normal engines just as well.

We have said before now in this journal that, so long as the grate and fire-box are big enough, there will be plenty of steam. Nothing will compensate for lack of capacity to burn coal. Mr. Deeley is of the same opinion, because he uses an enormous grate, with an area of 28.4 square feet, as against that of the simple engine with an area of 25 square feet. The simple engines, too, carry only 180 lb., or 40 lb. less than the compounds, so that they have none of that reserve to help them up banks which Mr. Deeley has conferred on the compounds. The loads are, moreover, the same within eight tons. It is probable, however, that their boilers are rather more economical, as the ratio of grate to heating surface is 1 to 61, while in the compound boiler it is 1 to 50.

Mr. Deeley makes a very remarkable statement concerning draught, namely, that a blast pipe, presumably smaller than that fitted to the simple engine, may be used. One of the stock objections to the compound engine is that the back pressure acts on a very large area of piston, and that therefore small blast pipes are quite inimical at once to high speeds and economy of fuel. In the absence of further information in the shape of diagrams it is, however, impossible to discuss this question with profit. No matter what may be the opinion held concerning compounding, it seems to be certain that Mr. Deeley has put in to service a large

number of extremely efficient as well as economical engines which represent in several ways a new departure in locomotive practice.

A Copper Trade Combination.

THE air has been charged with so many rumours during the past two or three months in relation to a suggested combination or trust in the United States copper industry that it is not without interest to hear of something definite in the shape of a scheme that possesses the element of probability at the present time. We refer to the reported conclusion of an agreement between influential parties to restrict the production of copper. It is a coincidence that as far back as last June the statistical report issued by the Frankfort Metall Gesellschaft, in referring to the upward tendency which seemed to prevail in the copper market at the time, stated that where price speculation was not concerned, the rise was due to the expectation of the introduction of a limitation in the output. The report added that interested circles only anticipated a lasting improvement in the conditions as a result of a considerable curtailment of the production over a long period. At the time the question was receiving attention in the United States, where the copper owning interests complain of overproduction, increasing stocks, and low prices for the metal. Since then individual mines have deemed it advisable to reduce the output of copper, and others, whilst maintaining the quantity of ore mined, have only had a portion of it smelted, leaving the remainder to accumulate as stock. The Calumet and Hecla mines, it is understood, are working at a restriction of 14 per cent., and the limitation in the case of the Phelps-Dodge undertaking also amounts to several per cent. But these individual efforts are entirely eclipsed by the agreement which is now announced as having been concluded between a number of the large interests, headed by the Amalgamated Copper Company, the Cole-Ryan group, the American Smelting and Refining Company—the Guggenheim enterprise—and the mines controlled by the American Metal Company. These undertakings, which rumour has previously credited with the intention of amalgamating, with a total capital of £100,000,000, have agreed to limit the output by 10 per cent. until further notice, and as they represent about 70 per cent. of the total American output of copper the magnitude of the scheme will be apparent.

The understanding between the large interests has been arranged on a basis which is growing in favour in the United States, and which is believed to be the controlling element in the working of the International Rail Syndicate. This is what is termed a "gentlemen's agreement," each party to which undertakes the obligation to observe the rules or arrangements decided upon without entering into written agreements. The system apparently owes its origin to the desire to avoid any contravention of the laws in the individual Federal States. At any rate, the important copper interests concerned expect that the reduction in the production will cause consumers to abandon their reserve and buy more largely, and thus result in an improvement in the situation of the market and of prices. The former do not propose, it is said, to raise prices unduly, but merely to obtain a suitable profit, whatever that may mean. The price of copper, which now amounts to from 13 to 13½ cents per pound, is, for instance, to be brought up to 15 cents, an augmentation which would be equivalent to an advance of from £7 to £9 6s. per ton. It remains to be seen whether this object will be accomplished by the promoters, and if so, whether they would be satisfied with securing such a price. If the interests represented by the scheme are able to force up the price in this manner it may be expected that the other copper producers will follow their example, both in the United States and in other producing countries, if, indeed, the movement should not be simultaneous and due to co-operation. A great deal depends, however, upon the question as to whether it will be possible to adhere to the arranged restriction in the production. A limitation is possible in the case of the low-cost mines, but where the prime costs are comparatively high the question is exceedingly difficult; and it has to be remembered that the Amalgamated Copper Company, which reduced the output two years ago in order to meet the fall in prices, was compelled to resume normal working, as the cost of production was too great when limiting the out-put.

It is therefore probable that the cost of production will play a not unimportant part in determining whether it will be possible to maintain the ten per cent. limitation that has been decided upon by the principal groups, apart from the restrictions of individual producers, such as the Calumet and Hecla, which are not included in the agreement. On the other hand, any inflation of prices would permit of the re-opening of mines which are not now worked owing to being unremunerative at the present price of copper; but the influence which these could bring to bear upon the situation would be inconsiderable, even if they were allowed to exercise it. It is calculated that the cost of production ranges from as low as 8½ cents per lb. to as high as 12½ cents per lb., as compared with the selling price of from 13 to 13½ cents. If, then, it were possible to raise the quotation to 15 cents, it might still be carried further, but the history of such artificial movements does not afford pleasant reading. Since 1886 the world's production has increased four-fold, and two great attempts have been made to control it. In 1887 the Secretan group, which is said to have been supported by the Rothschilds, succeeded in regulating from 80 to 85 per cent. of the world's output. The price was forced up from 12½ cents in 1886 to 17¾ cents in the first year of the copper ring, and to 19¾ cents in the following year; but the scheme collapsed, and the corner eventually liquidated its enormous stocks at from 10 to 12 cents per lb. A little more than ten years ago the Rockefeller group attempted a similar operation, which, although also successful for a time, finally fell asunder, with copper only costing 11 cents for several years. The South African War, the Russo-Japanese War, and the San Francisco disaster again produced a fresh rise to 17 to 18 cents. and the former president of the Amalgamated Copper Company then expressed the opinion that it was not to be expected that the quotation would ever fall below 17 cents. Yet so great are the possible fluctuations in the metal that three months after this statement was made the price declined to 12 cents per lb. It is possible, even probable, that a higher price than at present will prevail in the near future. Those who are engineering the American scheme, which is said to be merely a preliminary of a copper trust on the Steel Trust lines, will, however, have to bear in mind the possibility, not only of consumers continuing to curtail their purchases, but also of recourse being made to other metals, particularly aluminium, in the case of an attempt to secure inflated prices; for that matter the producers of aluminium are only awaiting an opportunity to flood the market with that metal.

Turbines in the United States Navy.

IT is impossible to over-estimate the naval importance of an experiment which has been very recently carried out by the United States Government. It is a matter of almost common knowledge that the efficiency of a warship depends largely on her range of action. In other words, how far she can go without having to refill her bunkers. This depends on certain factors, which are all variables. Thus, let us suppose that the consumption of fuel varies as the square of the speed. Then doubling the speed augments the consumption per hour or per day fourfold; but for any given distance the consumption is only doubled because the number of days or hours of steaming is halved. In practice, of course, for the higher velocities the consumption per hour augments in a much more rapid ratio. But the augmentation is not a fixed quantity. Every ship has a different rate. Again, we have the consumption of fuel varying with the power, because some powers are more economical than others. The general result may be summed up in a few words. For every ship there is a speed at which she can steam further per ton of coal burned than she can steam at any other speed. What this speed may be can only be determined by direct experiment. It is clear, however, that, particularly in the case of warships, the higher the velocity the better. So much premised, we may proceed to the experiment.

Two of the most recent additions to the United States navy are two Dreadnoughts. These are the Delaware and the North Dakota. It is claimed for them that they are the most powerful warships afloat. They are in all respects but their machinery sisters. Each can fire a broadside from ten 12in. and seven rapid-fire 5in. guns. Their displacement is about 21,500 tons, and their nominal or contract speed 21 knots, a velocity which has been considerably exceeded by both ships. The North Dakota was built and engined by the Fore River Shipbuilding Company, and is propelled by Curtis turbines, developing on the high-speed trials 31,400 shaft horse-power, which drove her at 22.25 knots. The Delaware was built and engined by the Newport News Shipbuilding Company. She has reciprocating engines, and on her trial attained a speed of 21.563 knots with 28,578 indicated horse-power. Now, in this country the results of what are virtually competitive trials are kept secret from everyone but foreign officers. But a more liberal policy prevails in the United States, and facts are given to the world. Not only were trials made to settle speeds and powers, but also incidentally to fix the range of action of the two great ships. A keen controversy is going on between the two shipbuilding companies to settle this point. On page 634 will be found a table containing the official figures, and we are told that the United States Bureau of Steam Engineering estimate that the North Dakota can steam about 5000 knots, and the Delaware 6000 knots, without quite emptying their bunkers—figures which do not appear to be justified by those in the table.

We now proceed to examine the facts in a little more detail; and, first, as to the consumption of fuel. Taking the main engines only, we find that at 12 knots, 19 knots and 21 knots, the Delaware required 15.48 lb., 12.7 lb., and 12.9 lb. of feed water per horse per hour. The North Dakota, at the same speed, required per shaft horse-power 20.6 lb., 14.25 lb. and 13.8 lb. Even after we have made an allowance for the difference between shaft and indicated horse-power, we find that the Curtis turbine is not so economical as the piston engine, and as was to be expected, this is particularly manifest for the lower powers. Every steam engine, whether it is a piston engine or a turbine, has a certain speed which is more economical than any other speed. In the Delaware the difference between best and worst is only 2.58 lb.; in the North Dakota it is 6.8 lb., or nearly three times as much. The Delaware, during a full-speed four hours' trial run on the 23rd of October, made 21.563 knots with 28,578 indicated horse-power and a coal consumption of 24 English tons per hour. The figures for the North Dakota have not reached us, but we deduce them from the published water consumption. At 21.64 knots she burned 28 tons per hour; taking the fraction of a knot higher speed into account, it may be said that the consumption —which is in American tons of 2000 lb.—was about the same for both ships. This is assuming that the boilers evaporated 8 lb. of water per pound of coal, which is the stated evaporation. Applying the same rule to the Delaware, we find that the consumption was 26½ tons per hour. We may take it that at these high velocities there was no substantial difference between the ships.

Turning now to the lower speeds, we find, calculating in the same way, that at 12.24 knots the Delaware burned 5.26 tons per hour, and the North Dakota, at 12.06 knots, 5.6 tons. The builders of the Delaware give the consumption as 4.3 tons per hour at 12 knots. The Fore River Company do not give any figures. If the builders of the Delaware are right then the boilers must evaporate more than 8 lb. per pound of coal. The Delaware made, we are told, 21 knots with 23,600 horse-power, 19 knots with 14,560, and 12 knots with 3520 indicated horse-power. It will be seen from the table on page 634 that at all these speeds the total weight of steam used by the North Dakota, including all auxiliaries, was in excess of that required by the Delaware. The data are, however, incomplete, in that nothing has been said—officially at all events—about the comparative efficiency of the propellers in the two ships. The probability, nay, the certainty, is that the propellers of the Delaware are more efficient than those of the North Dakota. But it is not necessary to go far into this question. We have only a certain number of facts to go upon, and these show that so far as range of activity is concerned, the turbine is, other things being equal, inferior to the piston engine. The highest average speed attained by the Delaware was 21.563 knots, and that, as we have said, was got with 28,600 indicated horse-power. The highest speed obtained with the sister ship was 21.64 knots—a scarcely appreciable difference, while the shaft power was 31,400, a difference of not less than 9 per cent. If we deduct 10 per cent. from the indicated horse-power of the Delaware engines we have 25,740 as the shaft horse-power, or but 82 per cent. of that of the North Dakota. These figures, inconclusive as they are, go to show that the propellers of the turbine ship must be much less efficient than those of the Delaware. This handicaps the turbine. But the turbine and the propeller are inseparable. They work together, and the naval architect must deal with them as a whole. The result of the experi-

ment seems to be so far adverse to the turbine. But the end is not yet. The last word has not been said concerning either turbines or propellers.

The New French Dreadnoughts.

THE provisional plans for the new French Dreadnoughts show that these vessels, although differing in minor details, in main principles closely resemble British designs, such as the Brazilian Dreadnoughts. So far as the big guns are concerned, the arrangement of the Minas Geraes is followed exactly. The only novelty is connected with the secondary armament. It consists of eighteen 5.5 guns, arranged in six quite novel three-gun casemates on the main deck. This arrangement suggests that all three guns might be put out of action by a single lucky shot. On the other hand, it allows of considerably more protection than can be given to a battery spread right along the main deck. Even as regards the liability of a lucky shot putting all three guns out of action, it may also be argued that the disposition of the secondary artillery leaves vast spaces, which may be hit without result, and by the mere law of chances it is these vacant spaces which are more likely to be hit than the casemates, so that quite a good case can be made out for the French idea. The new French ships will have three funnels and a couple of light masts; but about these there is nothing characteristically French. Indeed, the new French Dreadnoughts mark the abandonment of what, for want of a better name, may be called characteristic French design, and adhere very closely indeed to the latest British practice as evolved by our British private yards. Whatever may be said about French design, there remains the indisputable fact that not so many years ago, the only recipe for building a satisfactory warship was to capture a French ship and imitate her as closely as possible! Even in more modern times, despite many failures in French design, it should never be forgotten that the French were the only nation to ignore the low free-board battleship, and that it is to them that we owe the guns of high command which are now a feature in naval design all over the world. That the French should abandon their characteristic systems in favour of a design that is distinctly the evolution of our private yards at Elswick and Barrow is a compliment to British naval architecture, the full force of which is hardly to be appreciated at first sight.

OBITUARY.

DR. LUDWIG MOND.

THE death occurred early last Saturday morning in London of Dr. Ludwig Mond, the distinguished scientist and industrial chemist.

Dr. Mond was born in 1839 at Cassel, in Germany, and there he was educated until he began his career in chemistry by a course of study in that subject at Marburg and Heidelberg. His earliest application of the knowledge thus acquired was made, before he had reached the age of twenty-three, to an improvement in the Leblanc soda process. Several of the leading chemical manufacturers in this country became interested in his improvement—which consisted of a method for the recovery of the sulphur contained in the tank liquor remaining over from the final stages of the Leblanc method—and in 1862 he came to England, when his attention was directed to the carrying out of his ideas on a commercial scale. In 1864 he returned to Germany, where he remained for the following three years, having established chemical works for the production of soda at Utrecht. Thereafter he became permanently settled in England, where his subsequent discoveries were all made and set on a commercial basis.

The manufacture of sodium carbonate constitutes the main portion of the alkali industry, and in view of Dr. Mond's close association with the subject we may, perhaps, briefly indicate the developments which have taken place in the methods used for its production. In the Leblanc process common salt is acted upon by sulphuric acid to produce sodium sulphate and hydrochloric acid. The acid is taken off as a by-product, and the sulphate known as salt cake is mixed with limestone and coal dust and roasted. As a result, a mass of "black ash" is produced, containing crude sodium carbonate, with sulphide and oxide of lime, and other substances are present as impurities. This "black ash" is lixiviated with water, and on the tank liquor thereby produced being allowed to settle and concentrate soda crystals are deposited. It was with this process that the late Dr. Mond was identified in his earlier years, until Solvay introduced his ammonia-soda method, when, seeing its advantages over the older one, he and Sir John Brunner commenced working it in this country in 1873 under licence from the inventor. In the Solvay process a solution of brine is saturated with ammonia gas, the liquid being afterwards charged with carbon dioxide. The result is the formation of bicarbonate of soda and ammonium chloride. The first of these is converted into the carbonate by calcination, during which process carbon dioxide is driven off, and this is used for carbonating a fresh supply of brine. At first the success of the method commercially was doubtful, owing to the expense of the ammonia used as a reagent, but Dr. Mond soon introduced a method whereby its recovery from the last stages in the process could be effected, and thus permit of its being used repeatedly. Some years after he was enabled still better to compete with the Leblanc process by discovering a means for converting the chloride of calcium, hitherto a waste product of the reactions involved, into bleaching powder.

It is, of course, as the inventor of Mond gas that Dr. Mond will be chiefly remembered by engineers. For many years he had experimented on the production of cheap producer gas, and in 1893 his first producer was put into continuous working. His ideas in this direction are now well known to engineers, and need no description. We may add that, like all his other inventions, his method of producing gas shows a genius for taking advantage of all waste products and utilising them either to render the parent process more efficient or as a basis of operation in some new manufacture.

Among his other discoveries we have room only to mention that of the metallic carbonyls. In 1890, while experimenting on the utilisation of the hydrogen derived from the gas producer, he noticed that carbon monoxide had the power of combining with certain metals, giving rise to compounds some of which have remarkable properties. With the ability which he throughout his life displayed for adapting his scientific discoveries to commercial enterprise, he directed his attention towards the production of nickel from its ores. In the method introduced by him, and carried out on a large scale to-day at Swansea, carbon monoxide is passed over heated nickel oxide, so that the metal is first reduced and then caused to combine to form nickel carbonyl, $Ni(CO)_4$. When condensed this compound is a colourless volatile substance from which metallic nickel can be produced by heating it to 43 deg. Cent., carbon monoxide being evolved, which can be again used for the carbonyl stage. The chief advantage of this method lies in the fact that the metal is obtained free from the cobalt with which nickel ore is nearly always associated.

Dr. Mond was a Fellow of the Royal Society, and held honorary degrees from four universities—Padua, Oxford, Heidelberg, and Victoria. In 1889 he was president of the Society of Chemical Industry, and in 1896 of the Chemical Section of the British Association.

SIR ALFRED JONES.

On Monday night, at his house in Liverpool, Sir Alfred Jones, the head of the Elder Dempster Steamship Company, died in his sixty-fourth year. Sir Alfred was born at Llanelly, Carmarthenshire, and after receiving a sound, but plain education, entered, as a clerk, into the employment of the firm of which he ultimately acquired the chief control. About thirty years ago, through, it is said, his own intensity of purpose and ability, he bought out the original proprietors of the business, and assumed as his partner the late Mr. W. J. Davey. Since then the company has been developed by the enterprise and courage of Sir Alfred. As an instance of the manner in which he overcame obstacles, it is said that to popularise the banana, with the sea transport of which his steamships were chiefly engaged, he distributed freely a large quantity of the fruit to a number of costermongers in Liverpool, and instructed them to sell it at whatever price they could obtain in the streets.

His energies were not confined to the West Indies. The Canary Islands and the West Coast of Africa were benefited by his ability and industry, and the inhabitants of the former at least had cause to regard him as a benefactor to their race.

Outside his particular occupation his interests were varied and his activity great. He was the founder of the Liverpool School of Tropical Medicine in connection with the University of that city. For this service to science he received an honorary fellowship from Oxford University. The inception of the British Cotton-growing Association is also largely due to his initiative. As President of the Liverpool Chamber of Commerce, as Consul for the Congo Free State in Liverpool, and as Chairman of the Bank of British West Africa, his interests were varied and numerous. For his many services to the West African Colonies and to Jamaica, he was created in 1901 a Knight Commander of St. Michael and St. George.

EDWARD TANGYE.

As we briefly announced in our last issue, Mr. Edward Tangye—fourth son of Joseph and Ann Tangye, and brother of George Tangye, Heathfield Hall, Handsworth—died on Thursday of last week. Mr. Tangye was born at Illogan, Cornwall, on April 27th, 1832, and he was one of the five brothers Tangye, who among them founded and carried on the now celebrated Cornwall Works. In the early days he took an active part in the mechanical department of the rapidly-developing business, but after a few years, was compelled by a breakdown in health to recognise that he must give up the work which his strong bent for engineering made congenial to him, and retire.

He had, when young, devoted much attention to improved methods of horticulture, and had become an expert in fruit growing, hence it was not difficult for him again to turn his attention to this subject. He therefore returned to Cornwall and took up what doubtless he intended to be a more restful mode of life. But, as might have been anticipated, he found himself altogether unable to relinquish the fascination of mechanical invention, and soon was engaged in a study of the methods of manufacturing blasting fuse, a subject which had long before occupied the attention of his brothers James and Joseph. In this he achieved a marked success, and having designed and constructed automatic machinery of a novel type, he was soon engaged in the manufacture of an improved quality of fuse. This machinery, in its latest developments, is now used in the modern fuse factories of the Nobel Company.

Mr. Tangye, a few years ago, removed from his Cornish home to Knowle, where at Manor House, he resumed his horticultural work. Being a skilled pomologist he gave his special attention to the culture of apples of the higher qualities in which he was remarkably successful. Mr. Tangye leaves a widow and family of sons and daughters.

DIRIGIBLES AND AEROPLANES FOR THE FRENCH ARMY.

AMONG the questions which are likely to receive special attention during the forthcoming debate upon the army estimates in the Chamber of Deputies is the preparedness of France in the matter of dirigibles and aeroplanes. This has been impressed upon the public by the report of M. Capazza, the well-known aeronaut, who has recently visited Germany to find out what was being done in the construction of motor balloons. He ascertained that while France has been carrying out trials and experiments, and hesitating as to the types of machines most likely to render good service for military purposes, her neighbour has already created a formidable aerial fleet. At the present moment Germany possesses no fewer than twelve dirigible balloons—that is to say, six Zeppelin, three Parseval, and three Gross—while there are about fifteen dirigibles owned privately, and available for military use in case of need. The organisation of this fleet has been completed by the erection of huge sheds at different strategical points, which are each capable of containing six dirigibles, and Government has purchased considerable quantities of hydrogen gas, stored in cylinders ready to be despatched at a moment's notice to any part of the territory. The balloon corps is also being thoroughly trained to manage these airships in all kinds of weather. It is stated that the cost of creating this fleet has been close upon £100,000. In France, on the other hand, the only dirigible at present in service is the Ville de Paris, which has already depreciated in military value, and will be withdrawn as soon as it can be replaced, to be used for the training of pilots.

As the result of the public agitation aroused by this report, the Minister of War has been obliged, apparently against his own private convictions, to give more prominence to dirigibles in the army estimates. Because, however, Germany has lost no time in creating a fleet of motor balloons it does not follow that these are of greater value than flying machines for military purposes. She has built dirigibles because they are the best to be had at the moment, and the progress of aeroplane construction in Germany has been so much slower than in France that, as things go at present, it will apparently be a long time before that country will be able to rely upon flying machines as distinct from dirigible balloons. In a word, Germany is doing the best she can with the material already at hand without stopping to question whether the aeroplane will not eventually render still greater services. The French military authorities appear to have far less confidence in the motor balloon, the experience during the manœuvres, and the catastrophe to the République, having shown that its value for scouting purposes is distinctly restricted. It has been found that in order to be perfectly safe the balloon must fly at a height of about 5000ft., and from that altitude, except in the clearest weather, it is difficult to make accurate observations owing to the slight mist which almost invariably envelops the dirigible. Again, it is argued that if the balloon were pitted against the aeroplane it would have little or no chance, owing to the extreme mobility of the flying machine, which could attack the dirigible in any way it pleased. This, however, is by no means the opinion of French experts generally. M. Painlevé, of the Institute, who has been giving a great deal of attention to aviation, believes that it will take a generation to produce a sufficient number of aeroplane pilots to allow of this type of machine being used on any large scale. The aeroplane, too, will have to be greatly improved before it can be sufficiently reliable, and it is impossible to foresee whether the evolution of war machines will take place at an early date or will proceed slowly. It is therefore undesirable to place too much faith upon the immediate utility of the aeroplane to the exclusion of the dirigible.

The Minister of War is now endeavouring to satisfy public opinion by hastening forward the creation of a fleet of dirigible balloons, at the same time that he is carrying out preliminary arrangements for establishing an aeroplane corps. It is intended to render these two services entirely distinct, the dirigibles being confined to the Army Balloon Corps, while the aeroplanes will be placed in the hands of the Artillery. So far as the dirigibles are concerned, it has been decided to fit them all with two engines, which may be run together or separately, and the high-speed metal propellers of the type which proved fatal to the République will be replaced by low-speed wood propellers, while special arrangements will be made to avoid any possibility of explosion through the contact of gas with the exhaust. Two dirigibles, the Liberté and the Colonel Renard, are being modified in this way, and two others will be completed in the first half of 1910, so that in the course of a few months France will have at least four dirigibles capable of travelling at a rate of 30 miles an hour, and of rising to an altitude of between 6000ft. and 7000ft. without the use of sand ballast. It may be expected that, as the result of the forthcoming debate, the Chamber will vote funds to enable the Minister to purchase other dirigibles, while the fleet will probably be augmented by the funds raised by public subscription during the past few months. Meanwhile, Government has already completed a shed at Verdun, and others are in course of construction on the eastern frontier.

So far as concerns aeroplanes, the Government have decided upon taking an active part in the development of

VERTICAL COMPOUND CORLISS STEAM ENGINE

HICK, HARGREAVES AND CO., LIMITED, BOLTON, ENGINEERS

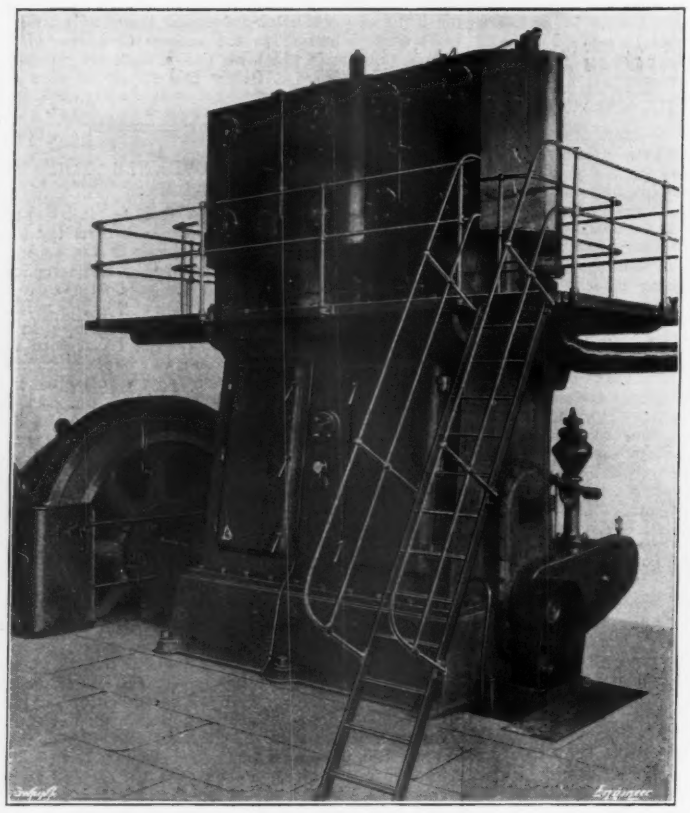


Fig. 1

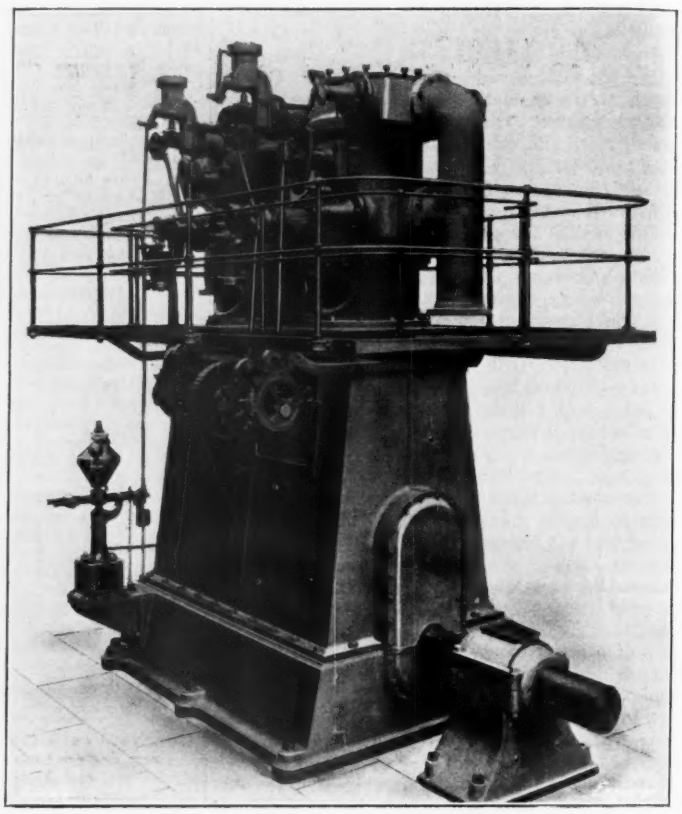


Fig. 2

these machines, for which purpose they have decided upon creating a laboratory between Nice and Marseilles, workshops for the construction of aeroplanes at Vincennes, and a school for the training of pilots on the aerodrome of Croix-d'Huns, near Bordeaux. The Minister of War has not yet fixed upon the type of aeroplane to be constructed by the Artillery, but he has purchased machines from different makers, with which trials are to be carried out, and it is upon the result of these trials that will depend the system of aeroplane which will be put under construction at the Vincennes works. While the military authorities are taking a practical interest in the design and construction of aeroplanes, the problem is one which appeals with special interest to French engineers and scientists, who are devoting considerable time to mechanical flight. Men of means have been coming forward with funds for the creation of laboratories, and it is characteristic that the first professor of aviation has recently been appointed at the Sorbonne, in the person of M. Marchais, Professor of General Physics at the University of Bordeaux. While, therefore, France will probably try to keep up with Germany in the creation of a fleet of dirigible balloons, she is likely to do more than hold her own when the aeroplane is sufficiently developed for military purposes.

A NEW PARTITION SLAB.

A FEW days ago we were invited to inspect the process of manufacture and the adaptability for building purposes of the "Muribloc" concrete slabs, which have recently been put upon the market by the firm of Muribloc Partition Slabs, Limited, of Prince's Wharf, Bridgend-road, Wandsworth, S.W. Special machinery has been designed for the manufacture of these slabs, by means of which the clinker used in their construction is crushed, mixed with cement, forced into the mould, compressed, and the finished product ejected ready for storage in the extensive maturing sheds which have been erected at the works. The principal advantages claimed for the slabs are low price, economy in fixing, strength, durability, fire-resisting, and sound-proof qualities. The slabs are made in three thicknesses, viz., 2½in., 3½in., and 4½in. The face dimensions are 27in. by 15in. The method of compressing the material consists of piercing holes almost completely through the slabs by means of a number of rods, which enter at one of the edges, whilst the mixture is enclosed in a definite space. The holes so formed are claimed to give the slabs exceptionally good sound-proofing qualities. Two of the edges are formed concave and two convex, thus enabling adjacent slabs to fit one within the other, the joints being made by means of cement. At the firm's works a small building has been erected with these slabs for the purpose of demonstrating the adaptability of the system and various methods of finishing. The system is claimed to be suitable for any buildings requiring partitions, or for the construction of estate walls, garages, bungalows, and other similar buildings. The system of coring above referred to, in addition to making the slabs sound-proof, also has the effect of making them light. It is claimed, in fact, that these are the lightest and cheapest fireproof slabs on the market. Another advantage claimed for the Muribloc slabs is that screws and nails may be driven into them with safety. We are informed that only clean clinker and the best Portland cement are used in the manufacture.

VERTICAL COMPOUND CORLISS ENGINE.

ALTHOUGH Corliss valves have hitherto only been used with comparatively slow running engines, it would seem that they can be made adaptable to engines running at medium speeds. The firm of Hick, Hargeaves and Co., Limited, Bolton, is now driving the machine tools in a portion of its Soho Ironworks electrically, the necessary power being provided by a novel design of a vertical Corliss engine coupled direct to a 400-kilowatt British Westinghouse direct-current generator. We are enabled to give illustrations of this engine, Fig. 4 representing a sectional elevation and end view, and Figs. 1, 2, and 3 different views of the engine and its valve gear. From these illustrations it will be observed that, with the exception of certain novel features, the design is somewhat on the lines of an enclosed high-speed engine. The engine has two cylinders, the high-pressure cylinder being 17in. diameter and the low-pressure 30in., the stroke of each being 24in. At a speed of 150 revolutions per minute, and with superheated steam at 180 lb. pressure per square inch, the engine is capable of giving off 600 indicated horse-power as a full economical load.

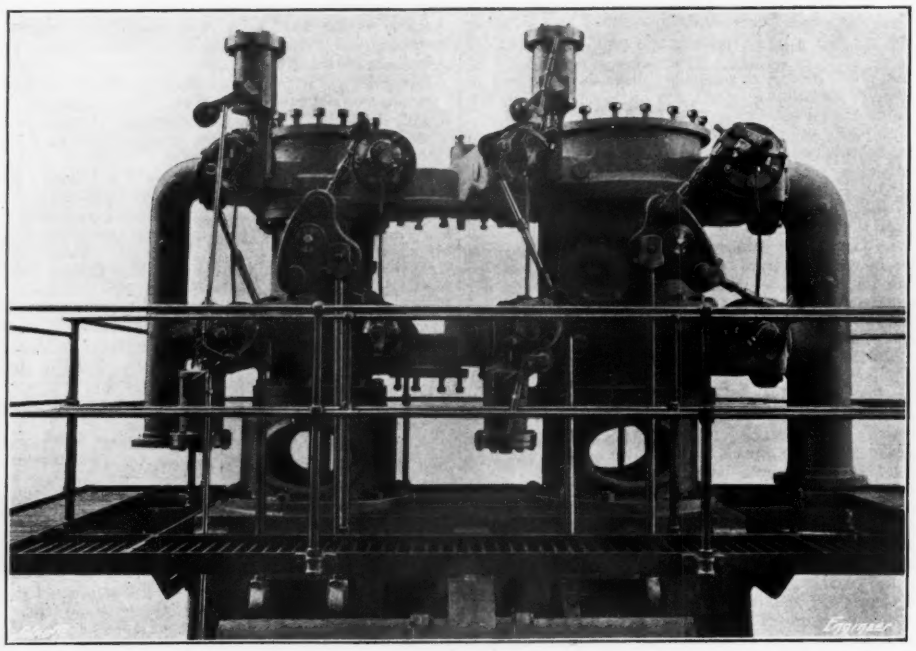


Fig. 3—THE CORLISS VALVE GEAR

As will be seen, the engine is built up in six essential parts—a base plate, roomy oil-tight crank chamber, two cylinders, and two open neck pieces between the cylinders and crank chamber. Bolted on to the outside of the crank chamber is a lay shaft, which is driven from the crank shaft by means of a Renold silent chain, the speed being the same for each shaft. The lay shaft is provided to operate the Corliss gear by means of four excentrics, two for each cylinder. The valves and valve gear are of this firm's usual standard pattern, the moving parts being made as light as possible, but to allow the rotary motion of the lay shaft to be converted into a vertical reciprocating movement on the wrist plate a ball-and-socket joint is provided on the top end of the excentric rod. This arrangement enables the crank shaft to be kept quite free of excentrics and simplifies the valve driving mechanism throughout.

The lubrication is forced throughout, the used oil from the base plate flowing into a tank, in which it is strained before being pumped back to the engine by valveless oscillating pumps, which are driven by a chain from the crank shaft. These pumps deliver oil under pressure into the main bearings, whence it is conducted to the crank pins and afterwards to the crosshead pins and slippers. The lubrication system is clearly shown in Fig. 4. A further application of the pitch chain is afforded by the governor. This is of Hick, Hargeaves and Co.'s sensitive type, and is driven from the

VERTICAL COMPOUND CORLISS STEAM ENGINE

HICK HARGREAVES AND CO., LIMITED, BOLTON, ENGINEERS

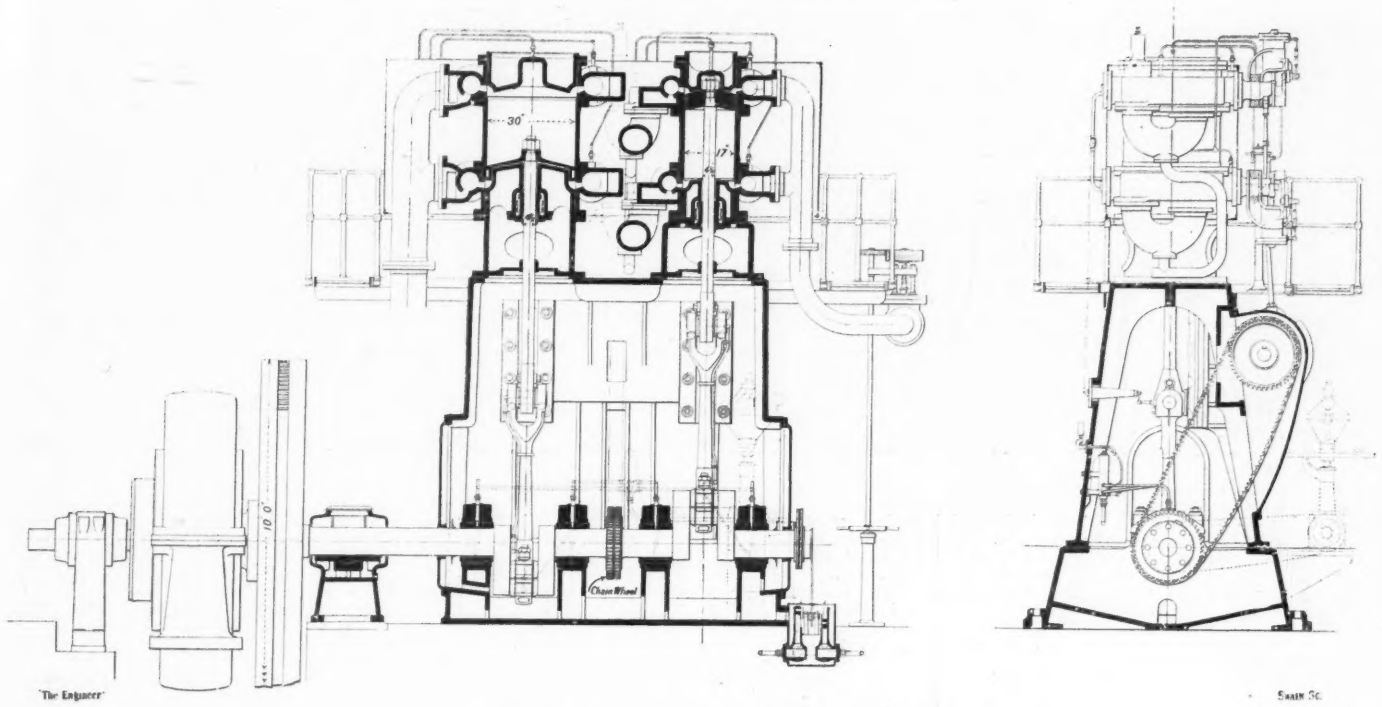


Fig. 4.—SECTIONS SHOWING THE OILING ARRANGEMENTS

crank shaft by a chain which is enclosed in an oil-tight casing, secured at one end of the engine.

The makers consider that this type of engine offers a useful compromise between the ordinary slow-speed, long-stroke engine with direct coupled generator, and the quick-revolution engine of the Willans, Bellis, or other pattern, also with direct-coupled generator. The advantages claimed are that, whilst on the one hand these engines do not call for so large or expensive a generator as the slow-speed type, they are, on the other hand, more economical in steam consumption than the high-speed engines with piston valves, particularly after the latter have been in operation for some time. The engine, in short, appears to combine in a large measure the best features of both the slow-speed and high revo ution types without many of their respective disadvantages.

NEW STEAMSHIPS FOR THE GRAND TRUNK PACIFIC RAILWAY COMPANY.

THERE was launched on Monday afternoon, December 13th, from the Wallsend shipyard of C. S. Swan, Hunter and Wigham Richardson, Limited, the twin-screw passenger steamer Prince Rupert, the first of two steamships which are being built to the order of the Grand Trunk Pacific Railway Company of Canada, and which will start early next summer a new service between Prince Rupert, the western terminus of the Grand Trunk Pacific Railway, and Vancouver, Victoria, and afterwards to Seattle or Tacoma. This route is some 750 miles in length. The Prince Rupert, along with a similar vessel, the Prince George, which, it is expected, will be launched at Wallsend early in the new year, has been designed by Swan, Hunter and Wigham Richardson, Limited, to meet special conditions, and is being built under the superintendence of Mr. T. L. Newman, of Victoria, British Columbia, the consulting naval architect for the Canadian Government and the Grand Trunk Pacific Railway Company.

The Prince Rupert has a smart appearance, having a straight stem and cruiser stern, which latter has been adopted in order to obtain the best lines to give a high speed. There will be two pole masts and three funnels. The length over all will be 320ft., the breadth 42ft. 2in., and the depth to the main deck 18ft. The ships are being built to the highest class under the British Corporation survey, and they will also comply with the Board of Trade regulations for passenger steamers. The gross tonnage of each vessel is 2850. The engines and boilers, with Howden's forced draught, are being constructed by the Wallsend Slipway and Engineering Company, Limited. The former consist of two sets of triple-expansion engines, balanced on the Yarrow, Schlick and Tweedy system, and are designed to give a speed on service of about 18 knots. On the shelter and shade decks of the Prince Rupert there will be accommodation in state-rooms of two berths each for about 220 first-class passengers. There will also be a few sets of state-rooms *en suite* placed on the shelter-deck amidships. Second-class passengers will be carried on the main deck forward. When occasion arises, about 1500 excursionists will also be accommodated. A feature of the first-class accommodation will be two spacious corridors running fore and aft, one on each side of the engine casing, and to enhance the general appearance, light will be given from several domes in a long roof, which will also have a clerestory. The dining saloon on the main deck is placed at the extreme after end of the vessel, and immediately forward of the dining saloon will be the stewards' pantries and the kitchens.

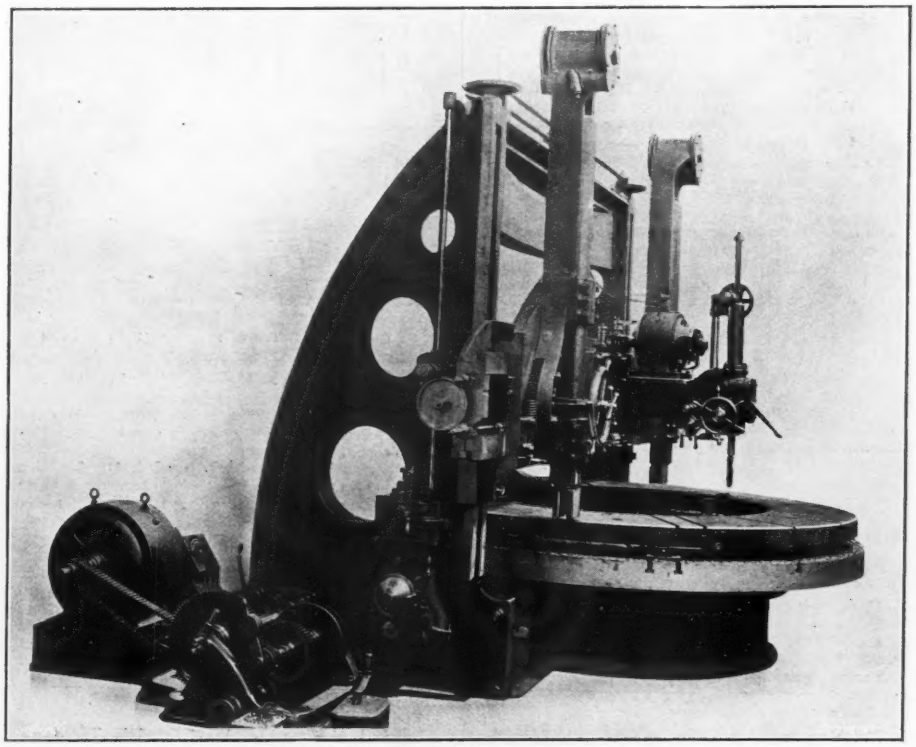
The Prince Rupert will be provided with a wireless telegraphy installation, refrigerating machinery for ship's stores and dairy produce, electric light, and steam heating throughout. The rudder is of the balanced type wholly below the water-line, and will be actuated by a telemotor steering gear.

Subsequently to the naming ceremony, a large party of invited guests were entertained in the mould loft of the Wallsend shipyard, and, responding to one of the toasts, Mr. F. B. Girdlestone, the general manager of the Bristol, Avonmouth, and Portishead Docks, made the announcement that, in the course of a short time, they would, by the co-operation of the Great Western Railway Company and the Grand Trunk Railway Company of Canada, have a service of high-speed steamships from the Avonmouth Docks, and thus open up a new and direct, and, indeed, the shortest route between London and Montreal. By the opening in February next of its new line affording direct connection to Avonmouth, the Great Western Railway Company would be able to cover the distance between Avonmouth and London in 1¾ hours. The new passenger and mail station alongside the outer wharf at Avonmouth was, he added, now nearing completion.

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES' ASSOCIATION.—The third general meeting of the session was held at the Institution, Storey's-gate, S.W., on Monday, December 13th, at 8 p.m., chairman, Captain Riall-Sankey, R.E. (retired). A paper entitled "Planning and Equipment of Turbo-Generating Stations," was read by Mr. Thomas Walmsley, graduate. The discussion was opened by Mr. P. Petrie, and the following took part:—Messrs. E. Timothy, H. C. Hodgson, A. J. Bremner, M. G. Duncan, S. A. Smith, A. C. Cartwright, and E. Seddon. Captain Sankey also made several interesting remarks.

BORING AND TURNING MILL WITH DRILLING ATTACHMENT.

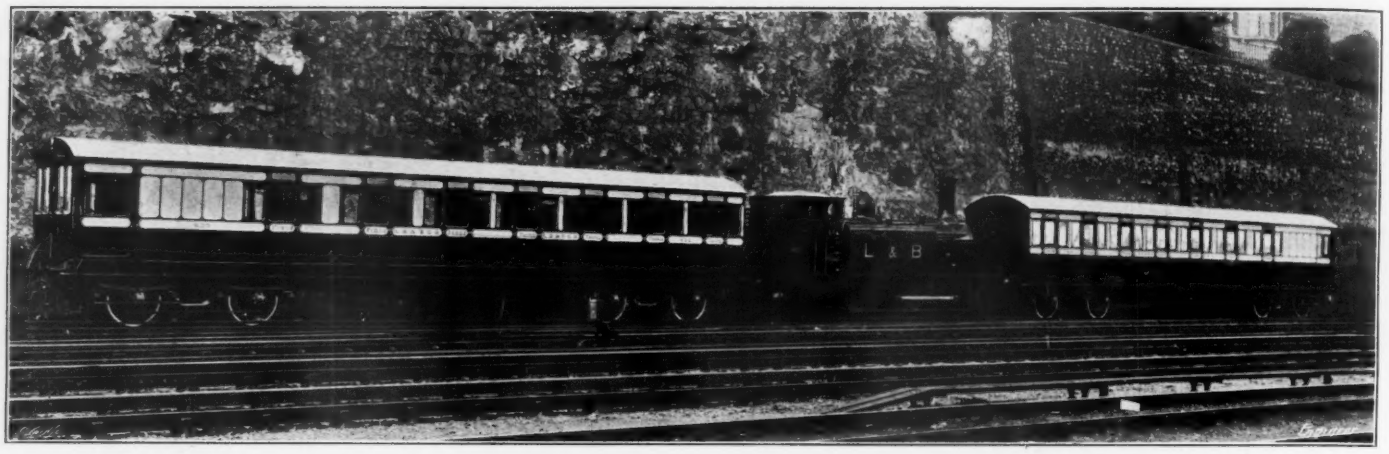
THE electrically driven boring and turning mill, of which we give an illustration below, has been specially adapted by the makers, George Richards and Co., Limited, Broadheath, Manchester, for dealing with circular steel doors and frames for bank safes. It will take work up to 14ft. diameter, and is fitted with the radial drilling attachment shown. The height admitted under the tool holders is 72in., and under the cross slide 82in., while the down feed is 48in. The cross slide has long guides giving a large bearing surface on the uprights, and bolts pass through these into the trough of the uprights, enabling the cross slide to be bolted firmly in position. The square slides which carry the tool bars are guided only by the lower member of the cross rail, ensuring greater accuracy and rapidity of the tool bars. These slides have a rapid movement along the cross slide by means of a rack, pinion, and ratchet handle. The swivel slides can be moved to an angle of 45 deg. on each side of the centre line for turning internal or external tapers. The tool bars are balanced by a spring balance arrangement, which does away with weights and chains and does not interfere with the manipulation of the machine by the operator. At each end of the cross slide a spring-slipping device is provided to prevent breakage to gears in case the two saddles collide. A positive



BORING AND TURNING MILL WITH DRILLING ATTACHMENT

MOTOR TRAIN ON THE EPSOM DOWNS BRANCH, L.B. AND S.C.R.

MR. D. EARLE MARSH, M. INST. C.E., BRIGHTON, ENGINEER



feed motion enables twelve rates of feed to be provided to each bar, and these can be instantly changed or reversed. The motor drive gives six positive changes of speed by gearing, while the motor has a speed reduction of 2 to 1, so that speeds suitable for any diameter of work up to the full capacity of the machine are possible. The drive from the motor to the machine is effected by a silent driving chain, the elevating motion to the cross slide is also driven from the same motor through gearing and a vertical shaft.

Fitted to the cross slide is a radial drilling attachment which, by means of a ratchet handle, can be moved to any position. The drill has a 3ft. radius, so that by the combined horizontal and radial movements and rotary motion of the table holes can be drilled in any position. The spindle is 2in. diameter, has 15in. self-acting and hand down feed, and is bored for a No. 4 Morse taper shank. This drill is driven by means of a variable-speed motor directly connected, and has back gearing and reversing motion, enabling tapping to be done up to 1¼in. holes. To enable the peripheries of the circular steel safe doors to have their multiple taper joints carefully ground, an electrical grinding attachment is used in the tool holder of the mill for grinding these after turning.

LAGOS AGRICULTURAL SHOW, 1910.

WE are asked by the Crown Agents for the Colonies to state that an agricultural show will be held in Lagos, the capital of Southern Nigeria, during the first week in December, 1910. It is hoped that a leading feature of the Show will be the section for implements and machinery suitable for the cultivation of tropical produce, and for its preparation for export and for local consumption. Medals and diplomas will be awarded, and machinists and implement makers are now invited to consider the desirability of preparing exhibits to compete in the above section.

For the information of firms not connected with Nigeria, it may be stated that the port of Lagos is the most important in West Africa, and the Colony and Protectorate of Southern Nigeria one of the most progressive, the total trade—imports and exports together—having risen from under four millions sterling in 1900 to over seven millions in 1908. The population of Southern Nigeria is about seven millions. Lagos is the terminus on the seaboard of the railway which is being constructed to Kano in Northern Nigeria, and the line was in September last open for public traffic for 307 miles, viz., up to Jebba on the Niger River. The following are the principal products which figure in the Southern Nigeria export list, and the quantities and values shipped in 1908 :—

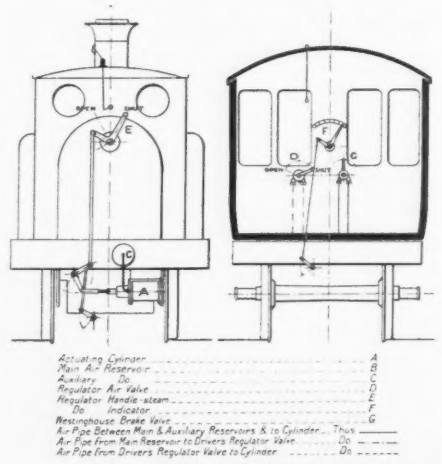
		£
Palm oil	18,300,000 galls.	1,155,000
Palm kernels	136,500 tons	1,424,000
Rubber	1,222,000 lb.	98,000
Mahogany	—	77,000
Lint cotton	2,300,000 lb.	53,000
Maize	15,500 tons	52,000
Cocoa	3,060,000 lb.	50,000

There is also a small export trade in fibre and coffee. In addition to the above, cassava is largely cultivated for local consumption, also yams, and, to a minor extent kola nuts, ground nuts, sugar cane, tobacco, peppers, indigo, &c. The following are some of the fruits grown :—Oranges, bananas, plantains, limes, pineapples, mangoes, pawpaws.

Exhibits of any simple implements or machines suitable for working the above products are cordially invited, but for the guidance of prospective exhibitors it should be noted that there are at present no draught animals working on the plantations and farms. Inquiries in Europe may, during during the rest of this year, and January and February, 1910, be addressed to Mr. R. E. Dennett, Provincial Forestry Officer for Southern Nigeria, care of the Crown Agents, Whitehall-gardens, London, S.W., and subsequently to the Commercial Intelligence Officer, Lagos, who will be glad to furnish exhibitors with a list of the local European merchants, in case they desire to establish an agency in Southern Nigeria for the sale of the specialities which it is proposed to exhibit. It is believed that the steamship companies serving Lagos, viz., Messrs. Elder, Dempster and Co., Liverpool, and the Woermann Linie, Hamburg, will charge only nominal rates of freight on exhibits, but definite information regarding this point may be obtained later by applying in writing to the Commercial Intelligence Officer, Lagos.

MOTOR RAILWAY SERVICE, LONDON, BRIGHTON AND SOUTH COAST RAILWAY.

THE London, Brighton and South Coast Railway has recently instituted a somewhat novel motor train service on its Epsom Downs branch. The train is made up of an engine and two bogie coaches, placed one at each end of the engine, and it is illustrated in the accompanying engravings. The



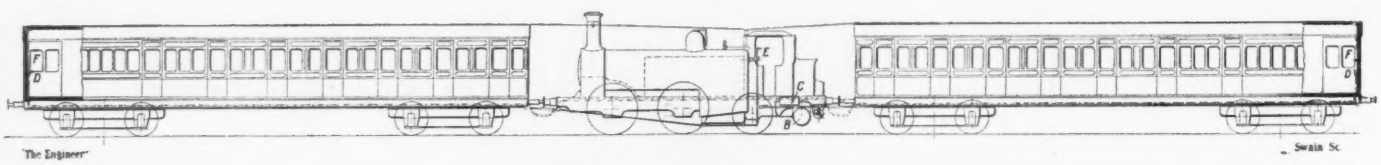
CAB AND DRIVING PLATFORM IN COACH

coaches are arranged on the compartment system, each containing three first and four third-class with luggage and driver's compartments. The total seating accommodation is for 128 passengers, and the length over buffers is 57ft. 7in. in each coach.

The engine has four wheels coupled, 5ft. 6in. diameter, cylinders 17in. diameter by 24in. stroke, with a boiler pressure of 150 lb. per square inch. It is 32ft. 3in. over buffers, so that the extreme length of the train is 147ft. 5in. The train is equipped with the Westinghouse brake, blocks being applied to every wheel of the cars and engine.

Advantage is taken of the air pressure necessary for the working of the brake to operate the regulator handle on the engine, which is worked from the end of either coach without in any way interfering with the action of the brake. A double-acting cylinder is attached transversely under the engine frame, its piston-rod linked to a lever on a short shaft; another lever on this shaft is connected to the regulator handle by a rod passing up through the footplate. The upper end of this rod is provided with a French pin, so that the regulator handle may readily be disconnected from the gear and worked by hand. In the cylinder an air-tight piston has a constant pressure of air on it, holding the regulator closed, the air effecting this passing first through a reducing valve from the main reservoir into an auxiliary reservoir, and thence into the "shut" end of the cylinder. Air at full pressure from the main reservoir is led to each end of the train, where, in the driver's compartment, it is controlled by a special valve with which the driver admits the high-pressure air to the pipes which lead it to the "opening" side of the piston. The reduced pressure on the "shut" side of the piston is overcome by the high pressure, the piston moved forward and the regulator opened gradually during such time as the driver admits air through his valve. On his closing the admission port of his valve, the regulator remains held in any desired position by the pressure on both sides of the piston. By releasing the air through the exhaust port of his valve, the pressure on the "shut" side of the piston closes the regulator. Should pipes or joints fail, or the coaches break away from the engine, the same result is obtained, as the reduced pressure is always in the "shut" end of the cylinder and the reservoir feeding it. An indicator on a sector worked through universal joints from the shaft reproduces exactly in each cab the position of the regulator handle on the engine.

To prevent interference with the apparatus in the cab at one end of the train while the driver is at the other, one handle only is provided for the two driver's regulator valves, and one for the two Westinghouse brake valves. The handle in each case is only removable from the valve it is being used for when the latter is in neutral position, and is transferred by the driver when he changes from one end of the motor train to the other. A whistle, blown by air pressure, is provided at each end of the train, and the engine whistle is also at the driver's command. We are indebted to Mr. D. Earle Marsh, the chief locomotive superintendent of the line, who designed the train, for the foregoing information and illustrations.



DIAGRAMMATIC VIEW OF THE TRAIN

EXAMINATION OF MARINE ENGINEERS.

THE following instructions to examiners and notice to candidates as to qualifications for a second-class certificate of competency as engineer of vessels propelled by oil engines, available for home trade passenger ships only, have just been issued by the Marine Department of the Board of Trade. On and after January 1st, 1910, candidates may be examined for the above certificates, the qualifications for which are as follows :—

(1) A candidate for a second-class certificate must be at least 21 years of age.

(2) He must prove :—(*a*) Four years' experience at the making or repairing of machinery, of which at least six months must be at the making or repairing of oil engines, or (*b*) Three and a-half years' experience in charge of engines and boilers at sea or an equivalent suitable experience on shore; and in addition to either (*a*) or (*b*), (*c*) Six months' experience with oil engines at sea. Note.—Alternative service to the above may be considered, but it is essential that the candidate should have experience with oil engines, and have spent at least six months at sea in the engine-room of a seagoing vessel.

(3) He must write a legible hand, and have a good knowledge of arithmetic up to and including vulgar and decimal fractions and square root. He must also understand the application of these and other rules to problems relating to spring and lever-loaded relief valves, and be able to solve questions about the relative speeds of a vessel at different revolutions, the capacity of oil tanks, &c.

(4) He must be able to give a clear explanation of the principle on which an oil engine works, and to show by means of illustrative sketches and otherwise that he understands the construction of those in general use.

(5) He must be able to describe the chief causes which may make the engine difficult to start, and to explain how he would proceed to remedy any defects.

(6) He must be able to show that he understands the mechanism of the starting and reversing arrangement, and is competent to deal with defects which may lead to failure in the prompt handling or reversing of the engine.

(7) He must have sufficient mechanical ability to be able to over-

haul the engine, to adjust the working parts, and to put the engine together again in good working condition.

(8) He must be able to give satisfactory answers to the elementary questions numbered 305 to 310 inclusive in the Regulations issued by the Board of Trade relating to the examination of engineers in the Mercantile Marine.

(9) He must be able to prove—by actual trial if practicable—that he is competent to manipulate an oil engine when under way by starting, running the engine, stopping, reversing or slowing down.

(10) He must understand what is meant by the flash point, and have a knowledge of the explosive properties of the oil generally used in oil engines when exposed in the open air, and the danger of exposing any vapour from the oil to a light, or of allowing any leak from the oil tanks, particularly into the vessel's bilges.

(11) He must understand the action of wire gauze diaphragms when placed in pipes and connections to oil tanks, &c., for the purpose of preventing the explosion or ignition of oil vapour therein.

(12) He must be able to take the necessary precautions to guard against the escape of inflammable vapour from the vaporiser when the engines are stopped.

(13) He must be able to explain the principle and construction of a dynamo and the construction and arrangement of primary and secondary batteries and induction coils, so far as is necessary for the efficient management of an oil engine.

These Regulations are to be considered as part of the Regulations relating to the Examination of Engineers in the Mercantile Marine (1908), issued by the Board of Trade, and the provisions of the latter will, so far as the nature of the case admits, and except where these Regulations specifically provide otherwise, apply to the examination of candidates for certificates of competency as engineer of vessels propelled by oil engines.

A NEW ELECTRICAL TOWER CRANE.

THE tower crane illustrated in the accompanying engravings was designed and constructed by George Anderson and Co. (1905), Limited, Carnoustie, Scotland, and is at present engaged on the building operations in connection with the extensions at the British Museum.

As will be seen from Fig. 2, the tower is composed of three sections, the divisions being made at the platform carrying the electric motors and their gearing, and at the platform supporting the sole-plates from which the two jibs of the crane spring. As a whole, the tower may be regarded as built up from four corner towers having each a rectangular cross section of 4ft. by 3ft. at their base, and of 18in. square at their highest point. Each of these corner towers has a height of 98ft. 6in., and is built up of four angles braced together diagonally and across by flat bars and gusset plates, similar

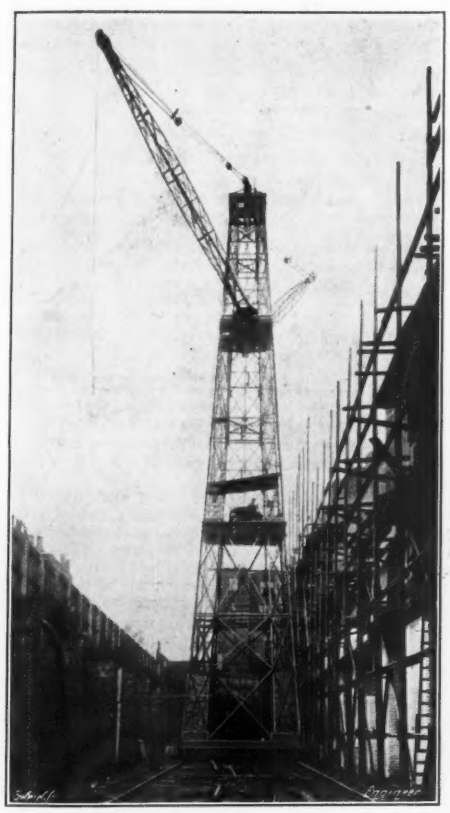


Fig. 1—TOWER CRANE

bracing being employed to connect up the four elements into the main tower. Half-way up each of the three sections into which the main tower is divided a diaphragm composed of stout angles and plates is introduced with a view to giving increased rigidity towards resisting torsional forces.

At the base of the tower where the section is 21ft. by 19ft. 6in., the structure is carried on a six-wheeled carriage composed of rolled steel joists, angles, and plates. A 10 horse-power motor is mounted on this carriage and transmits power to the wheels through cut steel spur and worm gearing for travelling purposes. At the top of the first section, at a height of 39ft. from the ground, the double set of gearing in connection with the jibs is carried on a floor composed of steel plates, channels and angle irons. The gearing required for hoisting, slewing and jibbing is driven for each jib by a separate motor of 20 horse-power, and all the movements, including travelling, are controlled from the motor floor At the top of the second section and 75ft. from the ground a floor is provided, and is carried on joists, channels and angles. The sockets, sole-plates and slewing gearing for the jibs are situated on opposite sides of this floor. Steel plates roof in the upper extremity of the tower, which has a rectangular section 6ft. 6in. square, and from the ends of a cross beam carried at this point steel links and pulleys support the jibs and provide the necessary means for radiating them. Each jib is of lattice steel-work construction, and is 45ft. in length. Provision is made for swinging either jib through an arc of 180 deg. A series of steel ladders is disposed in the interior of the tower, and gives facilities for reaching any of the three platforms.

With regard to the performance of the crane the following figures have been supplied to us by the makers:—At the maximum radius of each jib, 40ft., a load of 3 tons can be raised at a rate of 85ft. per minute, while at a 17ft. radius the crane can deal with a weight of 8 tons, the hoisting speed in this case being 36ft. per minute. The jibs can be used simultaneously, and when this is done each can deal with a 3-ton load at any radius up to the 40ft. limit. Forty-five seconds are taken to bring the jibs from their maximum radius to their minimum, while to slew them through their greatest arc of 180 deg. 30 seconds are required. A travelling

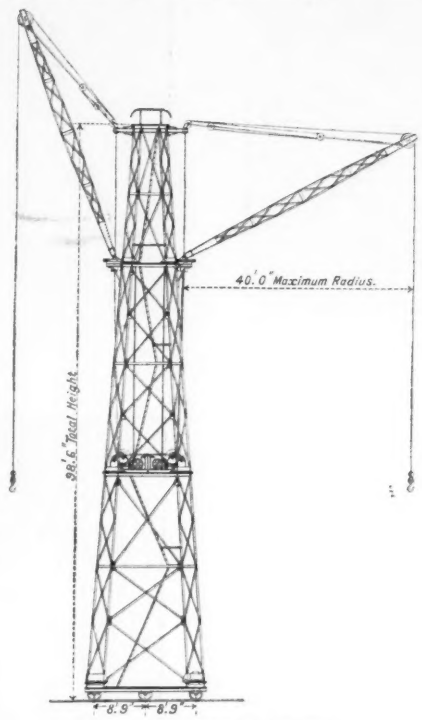


Fig. 2—ELEVATION OF CRANE

speed of 50ft. per minute is arranged for. During the working of the crane 12 tons of ballast are distributed on the travelling carriage, placed, as will be seen from the engraving, Fig. 1, in lots of 3 tons in each of the four corner towers.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

CENTRIFUGAL FORCE.

SIR,—"Pater" quotes Clark Maxwell's definition of accleration: "Any change in velocity, whether that change be an increase, a diminution, or a change of direction," and immediately afterwards writes, "There is no other definition or meaning given to the word acceleration save hastening," although he has just quoted two other definitions.

"Pater" is really questioning Newton's first law of motion:—"Every body continues in a state of rest, or of uniform motion in a straight line, unless compelled to change that state by the action of some external force." The velocity of the stone, "Pater" says, is constant; but it is not constant in a straight line. Therefore some external force is acting on it, or the above-quoted law is not true. It is quite clear by experiment that there is an external force acting on it, viz., the constraint of the string. The tensile stress, or stretch, of the string is the reaction to the inertia of the stone. Properly valued in direction and amount, it is the sole and sufficient cause of the change of direction, or acceleration, suffered by the stone. The angular velocity of the stone is constant, for there is no angular acceleration acting on it. Its rectilinear velocity is constantly changing, in accordance with Newton's second law:—"Rate of change of momentum is proportional to the impressed force, and takes place in the direction in which that force acts," for there is a force of constantly changing direction acting on it.

Why that force does no work on the stone is answered by the fact that it accelerates positively and negatively—or accelerates and decelerates—equally and evenly. Since the accelerating force is derived from the reaction to the stone's inertia under constraint it cannot increase the kinetic energy of the stone. Similarly, a bullet reflected from a target has its direction altered, and is therefore accelerated, but it will certainly not have its kinetic energy increased. It will be hastened in its new direction, slowed in its original one, both effects being due to a reaction force derived from its own inertia.

"Pater" instances gravity as an accelerating force. Gravity acts on a pendulum bob, accelerates it all the time in a constant direction, but does no work on it, and does not hasten it.

Your correspondent appears to have all "the law and the prophets" of mechanics at his elbow by his quotations. It is hardly likely that where they have failed to enlighten—as in the quotation with which I commence—your correspondence columns will succeed. "Pater" will find Glazebrook's "Laws and Properties of Matter" very clear on the laws of motion, the lines of reasoning and observation which have led to their acceptance and their use in calculation. He will find Chapter XXVII. and the latter part of Chapter XXVI. of Perry's "Applied Mechanics" clear up his particular difficulties with centrifugal force, so far as his difficulties are the usual difficulties of the student. He will certainly be pleased with the sentence in paragraph 481, containing a quotation from Erasmus.

But I suspect that his real difficulties are of a different kind. The questions he wants science to answer are of the class commencing with a "Why?" whereas, so far, scientific research has only managed to answer, somewhat imperfectly, a few questions commencing "How?" If he wants to get some answers to the latter sort of question for himself, he will find in Professor Perry's book aforesaid an instrument described for measuring centrifugal force. He may get some instruction from the observation of simpler devices. For example, a weight whirled at the end of an india-rubber cord, or a spiral spring, at different speeds, the elongation being noted, and the elastic string calibrated by known weights, will not only demonstrate the existence of centrifugal force, but measure it, and co-relate it with the weight, radius, and angular velocity of the mass. Allowing for errors of observation, and the disturbing influences of gravity, friction, &c., he will find his results agree with the accepted formula, which is the matter of practical importance.

If I am right as to "Pater's" real difficulties, perhaps the best advice is carefully to read Karl Pearson's "Grammar of Science."

London, December 13th. HENRY M. SAYERS.

THE DRIVER OF THE "ROCKET."

SIR,—In the obituary notice of Mr. Edward Entwistle, which appears at page 573 of your issue of the 3rd instant, you express considerable doubt as to his claim to have driven the "Rocket" on the occasion of the opening of the Liverpool and Manchester Railway on September 15th, 1830. I first became acquainted with Mr. Entwistle's name in that connection from a paragraph in the *Evening News* of April 10th last, but I did not pay much attention to it, as I regarded it as one of those stories of remarkable survivals which reach us every now and then from the New World.

Mr. Entwistle was born on March 15th, 1815, so that he would be only fifteen and a-half years of age on the day of the opening of the railway, and, according to his account, Stephenson engaged him just two days before that momentous occasion to drive the "Rocket," the engine which gained the prize at the Rainhill competition in October of the previous year. This story is ludicrous, and as you say, "doubts have been expressed as to the probability of a careful man like George Stephenson selecting a youth for such an important task." Those who favour Mr. Entwistle's claim should remember that Stephenson had no less than eight locomotives on the line at the time, the names of which are well known, and that all these engines had been "repeatedly tried, and with success, several weeks before"—*Mechanics' Magazine*, September 25th, 1830, page 65. Is it at all likely that Stephenson would displace the regular driver of the "Rocket," and put an inexperienced boy on the foot-plate? It is reasonable to suppose that Stephenson had at his disposal at the time a pick of drivers, and that even had the supply fallen short he would have appointed a fireman, not an absolute novice.

I have consulted four newspapers of the day to see whether the name of the driver is given in the report of the inquest which was held upon Mr. Huskisson, but he is referred to only as "the engineer." The unfortunate accident created a great sensation throughout the country, and the appearance in the witness-box of a boy under sixteen would certainly have provoked comment.

I am, however, in a position entirely to disprove Mr. Entwistle's claim. The name of the driver of the "Rocket" on September 15th, 1830, was White. My authority for this is the report of the opening of the line in the *Morning Herald*, quoted at page 66 of the *Mechanics' Magazine*, cited above. R. B. P.

London, December 15th.

HUMPHREY'S PUMP.

SIR,—In your issue of December 10th, 1909, at the top of the first column on page 611 you make me say that my figures of comparative fuel costs taken from Mr. Humphrey's paper show "that the Humphrey pump was more economical than any other form of pump, as the author had stated in his paper." My figures, which you correctly give, prove the exact opposite, and were offered for Mr. Humphrey's criticism. They were as follows:—

Humphrey—Mond	37	Relative fuel costs.
Humphrey—anthracite	26.5	
Compound steam engine pump	20	
Triple-expansion "	16.6	

Birmingham, December 14th. HENRY LEA

[The fact that "not" had dropped out was no doubt noticed by our readers.—ED. THE E.]

SIR,—I regret that I made an error in my calculations regarding the length of pipe required for the Humphrey pump to which I referred at the recent meeting of the Institution of Mechanical Engineers, and reported on page 611 of your last issue; 73ft. of 4ft. 9in. diameter pipe is, of course, equivalent to 18.25ft. of 9ft. 6in. pipe, so that for one pair of cylinders there would be required 36.5ft. of 9ft. 6in. pipe, and not 13ft. 6in. as stated previously.

I shall be glad if you will kindly insert this correction.

London, December 10th. J. F. ROBINSON.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—The annual dinner of the North-East Coast Institution of Engineers and Shipbuilders was held at the Armstrong College, Newcastle-on-Tyne, on Friday, December 10th. In submitting the toast of "The North-East Coast Institution of Engineers and Shipbuilders," the Duke of Northumberland recalled the opening address of their first president, Mr. William Boyd, in which appeared the remark: "I imagine no shipbuilder or naval architect among us will contend that the best type of vessel is already designed, and that the ship of to-day is incapable of improvement." Looking back over those twenty-five years he (the Duke) could not help thinking that was a very pregnant remark. As a child he heard of a vessel called the Great Eastern, which was not altogether a success, and people said that nobody would be foolish enough to build so big a vessel as that again; yet time had gone on, and they had seen the Mauretania built beyond the proportions of the Great Eastern. Again, their first president said that attention required to be paid to the employment of higher working pressures of steam in steamships. Mr. Summers Hunter, in responding, said that to keep their position in the manufacturing world they must continually aim at being in front. Although possessing no politics, there were matters of Imperial moment that greatly concerned their Institution. For instance, they had heard a good deal about the "All-Red" route for their shipping, and that, they hoped, would eventually be accomplished, but along with the "All-Red" route, if not in front of it, should be what he called the "All-White" route, or the white ensign of the British Navy, to protect the "All-Red" shipping route, and also to show that there was an Imperial, as well as a commercial connection between every part of the British Empire. The "White" route required more ships, more men, and greater efficiency. They greatly valued the man behind the gun, but there was a man behind him, down in the engine-room, for whom they claimed more recognition. The solution of the status of the naval engineer was only to be found in the complete fusion of the executive and engineer branches and in the engineers having control in their own department with identical titles and uniform. Sir Hugh Bell, in submitting the toast of "The Trade and Commerce of the North-East Coast," said that he had calculated that it took just about £200 or £250 to put a man to work in the industry in which he was engaged. For every £200 they had invested, one man directly employed by them was obtaining a livelihood, bringing up a family, providing citizens for the State in future, and discharging all the duties of a patriotic member of the community. For that the capitalist received at the very outside 10 per cent., very often much nearer 5 per cent.; £10 per year, therefore, was about what any captain of industry might receive for such a man. What did the man receive? The amount of wages paid to him and those in connection with him was very nearly £150. This consideration had an important bearing upon industrial matters at the present juncture. Lord Joicey, with whose name the toast was coupled, in responding, said that with reference to the Coal Mines Eight Hours Act he was glad to tell them that in Northumberland and Durham they were likely to come to some arrangement to carry on their business under this Act without having any serious stoppages.

REPAIRING A FRACTURED ROLL MILL HOUSING

THERMIT, LIMITED, LONDON, ENGINEERS

Fig. 1—THE FRACTURED HOUSING

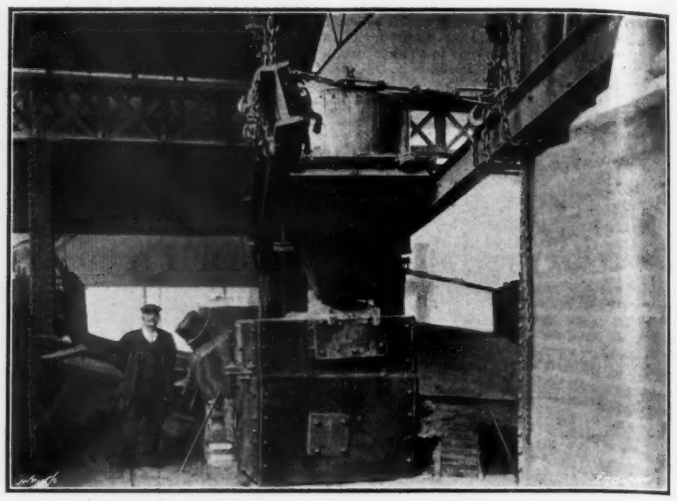


Fig. 2 CRUCIBLE AND MOULD IN POSITION

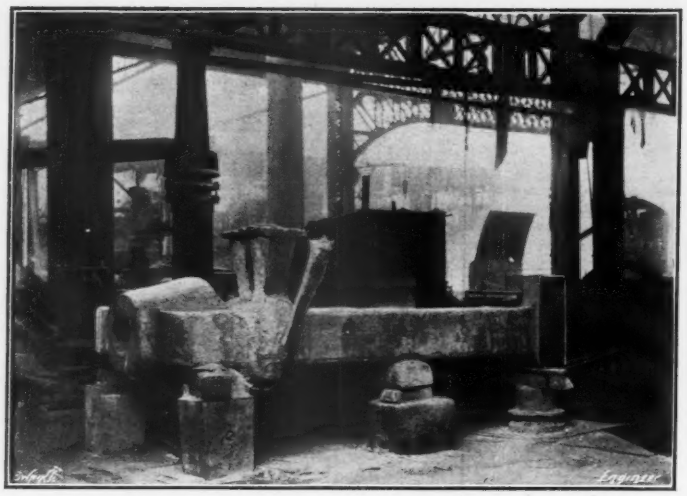


Fig. 3—ONE WELD WITH RUNNER AND RISERS ADHERING

Fig 4.—THE REPAIRED HOUSING

REPAIRING A ROLL MILL HOUSING.

AN interesting repair has recently been carried out on a broken roll mill housing by means of the Thermit process. The housing was a steel casting which was broken through each side near the top, as seen in Fig. 1. Sections of the broken part and of the Thermit band welded on are given in the accompanying sketches, Figs. 5 and 6.

To effect the repair two welds were necessary, one on each limb. The broken part was secured in position, allowing for a 2in. space between the fractured ends. A wax pattern was formed round one of the breaks, the mould box fitted, and the mould, which was made from a mixture of two-thirds silica sand and one-third fireclay, was made in the usual way on the casting. The parts were preheated by means of two petrol and compressed air torches, which also dried the mould

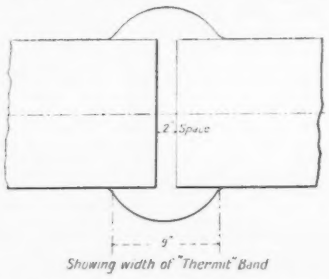


Fig. 5—LONGITUDINAL SECTION AT WELD

in position and melted out the wax, leaving space for the Thermit steel.

The crucible was placed in position, the compound ignited and tapped as soon as the reaction was over. After the weld had cooled sufficiently the mould was removed and the second weld made in the same way. The fractured ends were drawn together while the weld was solidifying to relieve it of contraction stresses. The welds were subsequently annealed for 48 hours. For each weld 18½ cwt. of Thermit compound were used, together with the necessary additions. The weight of the broken casting was about 15 tons.

The repair was carried out by Messrs. Thermit, Limited, of 27, Martin's-lane, Cannon-street, E.C., for a firm of engineers in the Black Country at the end of last month, and occupied ten days from start to finish. The repaired casting appears, so we understand, to have been perfectly satisfactory, and is now again in use. The engravings which, by the courtesy of Thermit, Limited, we give above, speak for themselves and require no explanation.

For those of our readers who are unfamiliar with the Thermit process, we may say that it depends for its action on the affinity of aluminium for oxygen—or, in other words, on the reducing properties of the metal. In practice, a composition made up of a mixture of finely granulated aluminium and the oxides of metals is employed. When steel is to be welded the oxide of iron is employed. This mixture is ignited by means of a special ignition powder, and the combustion when once started spreads through the whole mass, a great heat being evolved, steel being easily melted as well as other refractory metals.

We may add that we are informed by Thermit, Limited,

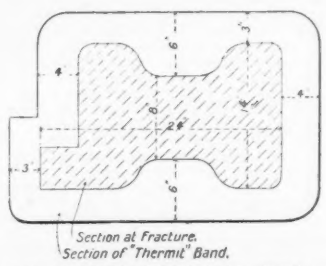


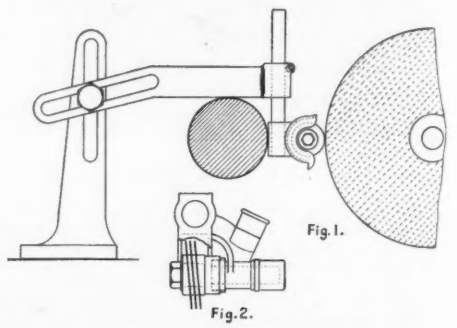
Fig. 6—CROSS SECTION AT WELD

that the British Corporation for the Survey and Registry of Shipping, of Glasgow, has recently sanctioned this process for repairs to fractured stern-posts, lower portions of rudder frames, and other damages of a similar character.

IN the heating and domestic engineering trade disputes have been caused within the last few years in some districts by the action of the plumbers in claiming a monopoly of pipe fitting and fixing work in all metals, whether lead or not, to the exclusion of any other trade. The engineers have all along been willing to submit the matter to arbitration, and a step in this direction has now been taken in connection with a dispute on the New Masonic Hall, Leicester, where the plumbers, in pursuance of their claims, withdrew from their own work. Lead work is not in dispute, as it is not touched by the engineers. After protracted delay the plumbers agreed to the appointment of an arbitrator, who has decided that no claim has been established giving to plumbers the exclusive right to fit and fix all pipes and fittings in hard metals used in connection with ventilation, heating, warming, laundry, cooking, and general hot and cold water domestic or other supplies or services. This award upholds the claim of the heat and domestic engineers to do the work in question, and establishes that all lead work be considered plumbers' work, but that a neutral line be taken as regards all iron, brass, copper, or other metalwork, which may be executed by engineers or plumbers.

DRESSING GRINDSTONES.

THE extensive use of grinding in the machine shop has called into being a number of devices whereby the grinding wheel may be dressed and trued from time to time as occasion arises. In the example of this class of tool herewith illustrated the makers, Messrs. Brunton and Trier, of Great George-street, Westminster, claim to have evolved a design free from certain objections to be found in others, and possessing several virtues of its own. Two forms of this tool are obtainable. In one the instrument is held during the dressing operations by hand against the wheel, and is provided with a hook to catch on the tool rest of the stone. In the other design herewith illustrated, the tool is held securely by an



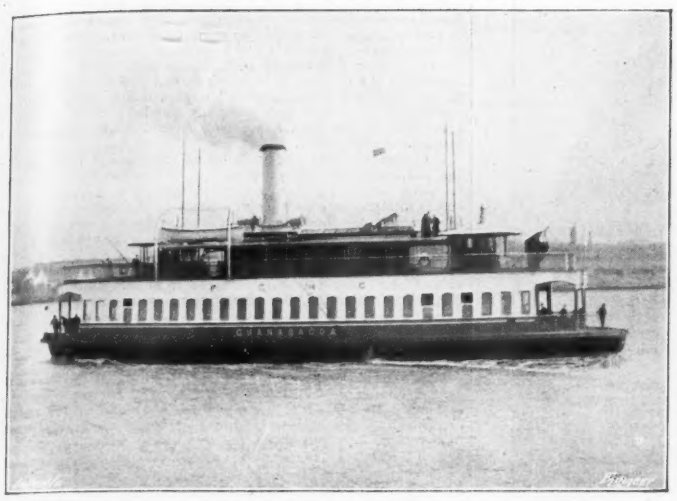
GRINDSTONE DRESSING DEVICE

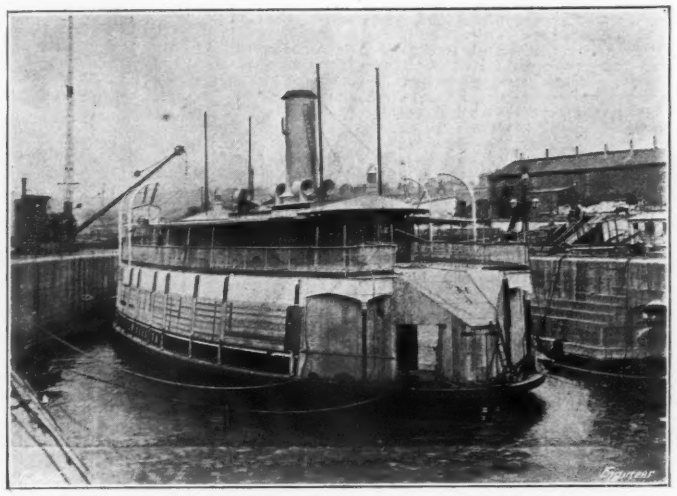
adjustable arm, so that the wheels of grinding lathes and such-like machines can be trued with great accuracy.

The form of cutter used will be seen from Fig. 2. A spindle running in a dust-proof bearing carries several discs lying at an angle with the axis of the spindle. These discs are made of specially hardened thin sheet steel and are arranged so that their edges lie on a true cylinder whose axis is coincident with that of the spindle. When the cutter is brought into contact with the emery wheel the oblique setting of the discs causes them to move across the edge of the wheel and thus, by their wedge-like action, they cut down any inequalities or roughness. In Fig. 1 the cutter is shown applied to the wheel of a machine adapted for grinding between centres. The supporting arms are so arranged that the thrust of the wheel on the cutter is taken up by the work in the lathe.

THE FERRY STEAMER GUANABACOA

CAMMELL, LAIRD AND CO., LIMITED, BIRKENHEAD, BUILDERS





THE FERRY STEAMER GUANABACOA.

THERE has recently left the works of Cammell, Laird and Co., Limited, Birkenhead, a double-ended ferry steamer, 140ft. long, 38ft. moulded, 55ft. extreme beam, and 14ft. 3in. moulded depth, the first of her type built in England. The whole of the work, which was completed in the short time of four months from the date of the order, has been designed and supervised by James Pollock, Sons and Co., Limited, of 3, Lloyd's-avenue, London, E.C.

The vessel has two propellers, one at each end. On the official trial which was recently carried out a speed of 11¼ knots, ¾ of a knot over the guaranteed speed, was obtained. The weather was anything but favourable, and as a very strong breeze was blowing at the time, this speed was considered to be an excellent achievement. The vessel is fitted at either end with a Pollock's patented stern frame, which is designed to reduce the friction and to enable the boat to be fitted with a larger propeller than is possible with the ordinary frame. The manœuvring qualities were on the trial found to be good, the vessel turning round a complete circle, in a radius about twice her own length.

The steering arrangements are elaborate, and the following methods can be used from either pilot-house on the promenade deck:—Steering by means of (1) two rudders by steam power, (2) the after rudder by steam power, (3) the two rudders by hand power, and (4) the after rudder by hand power. There are eight distinct and separate arrangements for locking the rudder which is not in use.

The engines, which are of the inverted compound surface-condensing marine type, were built by the contractors, and have cylinders 19½in. and 42in. by 27in. stroke. They indicate 940 horse-power when running at 148 revolutions per minute. They are arranged to drive one propeller at each end through one line of shafting running the entire length of the vessel. The handling gear for the main engines is arranged on a wrought steel quadrant in the engine-house on the main deck.

The docking and handling arrangements consist of a non-reply system of telegraph from each pilot-house leading to one indicator in the engine-house, special transmitters or indicators in each pilot-house, so arranged that the handles are moved in the direction the vessel is intended to travel, and a complete set of jingle and docking bell signals and gongs.

Each pilot-house is fitted with an indicator, so that the captain can ascertain the direction in which the main engines are running, and also the revolutions per minute they are making. A similar arrangement is also fitted in the engine-house for the use of the engineers.

The aft end of the engine-house facing the engine-room is practically all glass, so as to give the engineer in charge of the levers a view of the engine-room and the main engines. The floor is laid with small black and white tiles. A switchboard controlling all the electric lights in the ship is also fitted in the engine-house. The condenser is independent, and is connected to a centrifugal pump and a vertical direct-acting air pump, which maintained a vacuum of 27in. throughout the official trials. The feed pump is of the vertical simplex type, with an automatic control arrangement. Besides these pumps the equipment includes a vertical auxiliary duplex feed pump, which can also be used for general services. A large fire and salvage pump is also fitted.

The Guanabacoa is fitted with a complete electric light arrangement. The wiring is carried out on the two-wire system. The lights throughout the ship are grouped in sections, and each section is controlled by a switch on each deck, these again are controlled by the switches on the main switchboard in the engine-house. Two dynamos are provided, a smaller one is installed for economical reasons and for use when only a few lights are required. The navigation lights are in twin sets, and are controlled by special switches in the pilot-house. They are so arranged that when one set is put on the other set is put out. There is a small pilot light to notify the pilot if the right lights are on or not.

The boilers are of the Babcock and Wilcox water-tube type, two in number. They blow off through a silent blow-off valve at 225 lb. per square inch. This pressure is reduced through a reducing valve to 150 lb. per square inch, under which pressure the engines are designed to work, and steam can be used direct through a by-pass should the boiler pressure be low. All the auxiliary machinery works at full boiler pressure.

The main saloons are arranged on either side of the main deck, the entrance being through double doors opening outwards at either end of the vessel, and from the upper deck by means of a double staircase. The floors are covered with interlocking rubber tiles. Special windows at the side of the vessel, each 5ft. by 2ft. 6in., extend the whole length of the saloons. Seats are fitted all round the saloons. Cartways for the accommodation of vehicular traffic run between the saloons and the engine casings. Collapsible gates are fitted at each end of the main deck in place of the ordinary bulwark gates. The upper deck, which extends the whole length and width of the vessel, has accommodation for about 1000 passengers.

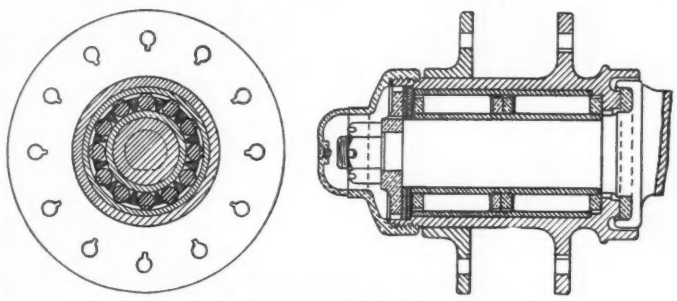
The pilot-houses, which are of teak, have curved plate-glass in front. The floors are covered with interlocking rubber tiles as used in the saloons. All the windows are arranged to lower, and are fitted with plate-glass.

The sun deck, which is 7ft. 6in. above the promenade deck, is of pine covered with canvas and painted green, on which are fitted the side-light screens and the lifeboats, which are of steel; they are arranged to lower overboard by hollow steel davits.

We are enabled to give two views of this vessel. One of these shows her undergoing her official trials and the other gives a view of her as she appeared in dock at Liverpool, boarded up preparatory to making her journey to Cuba, where she is to be employed.

ROLLER BEARINGS FOR ROAD MOTORS.

THE rapid deterioration of the bearings and axles of motor omnibuses is largely due to the excessive friction and the severe stresses called into play by the uneven nature of the surface of the streets and roads over which the vehicles have to pass. Sudden starting and stopping likewise subject the bearings to stresses of a similar nature, and in many cases the wear and tear so caused is a fruitful source of trouble and repairs. To avoid these, and consequently to decrease the cost of maintenance, the Empire Roller Bearings Company, of Westminster, has recently designed and constructed the form of axle arm roller bearings illustrated in the accompanying engraving. These bearings consist of two steel sleeves, the inner forming a bush for the axle journal and the outer a liner for the wheel hub, between which two sleeves hardened cylindrical steel rollers are disposed. The rollers, of which there are two sets in each hub, are prevented from twisting by the patented gun-metal cages which also separate each roller from its neighbours. End collars and nuts of the usual pattern are employed to secure the wheel to the axle, and in appearance the outside view of the bearings is quite similar to that of the ordinary type. The sleeves and rollers are made from a special quality of steel, hardened and ground to a true fit. The design of these bearings is the result of a long experience of, and experiments with, a similar class of goods as applied to railway and tramway rolling stock. We are informed that recent trials with them have shown a considerable saving in petrol consumption, while the small amount of lubricating oil required and the ease with which the vehicles were started, run, and stopped were other marked features of the tests.



ROLLER BEARINGS FOR MOTOR OMNIBUSES

MANCHESTER ASSOCIATION OF ENGINEERS.

ON Saturday last, Mr. J. S. Peck read a paper before the members of the above society on the "Distribution and Application of Electric Power." Mr. J. H. Stubbs, the President, occupied the chair. The author first described in a general way the different systems of generation and distribution. By means of simple analogous diagrams the operations of the various types of electrical apparatus were described in terms easily understood by mechanical engineers. Then, after dealing with general principles, Mr. Peck proceeded to describe some of the most recent types of electrical apparatus, including turbo generators, transformers of various types, rotary converters, current controllers and starting mechanism.

He conveyed as clear a meaning as could be desired in the course of a short paper of the term "power factor," applied to alternating-current work. He said that with direct current the power was equal to the pressure multiplied by the current, just as in hydraulics the power equals the head multiplied by the volume flowing. Where the current was alternating, however, the power was calculated by multiplying the pressure by the current, and by a term called the power factor. The reason for this was that under certain conditions work was done in the circuit during a part of the cycle, and was returned during another part of the cycle, so that the resultant energy supplied over the complete cycle was represented only by the frictional losses. In an electrical circuit power = volts × effective current; but the effective current = total current × cos ϕ, where cos ϕ was the angle between current and voltage. But cos ϕ = power factor of the circuit. Therefore the power = watts = electromotive force × current × cos ϕ = E × C × power factor.

He remarked that the only really important change made in direct-current motors in recent years was the addition of commutating poles on shunt motors where these are required to give a wider range of speed variation. Before this feature was introduced most manufacturers hesitated to guarantee more than a 2/1 speed variation, whereas a speed range of from 4 to 6 to 1 could now be guaranteed. The use of commutating poles was also coming into favour for large motors and generators even where no speed variation was required, as their use permitted certain economies in the design of the machine. The function of the commutating pole was to give good commutation under severe working conditions.

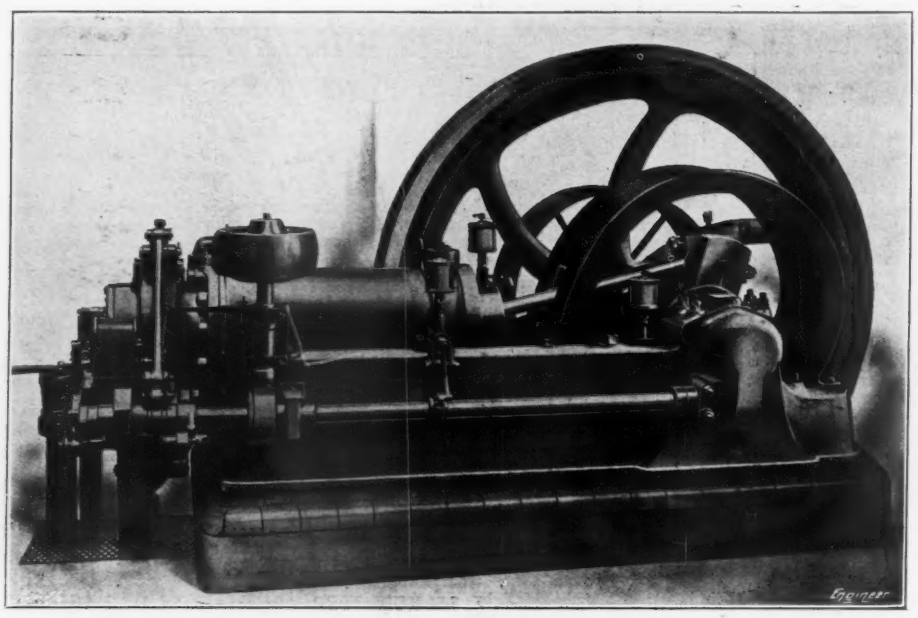
With regard to the synchronous and induction motors the author said that these were constant-speed machines, since the synchronous must run in exact step with its generator, and the induction machine runs at a speed very slightly below synchronism. Except for variable speed working they were, however, successful and efficient machines and had a number of points of superiority over the direct-current motor.

As the paper was not of a controversial character, the discussion which followed was scarcely germane to the subject and chiefly limited to questions of cost of generation of electric energy. In this connection Mr. Creek spoke of the splendid opening which flour mills presented for the use of electric power, as they were run without a break from Monday morning to Saturday night. He said, however, that unless power could be obtained at 0.4 penny per unit, electricity could not compete with steam power in this class of work. Mr. Watson, who followed, said that current could be obtained from power supply stations at even a smaller figure than 0.4 penny. Mr. Cook said that current could not be generated profitably for so small a sum, and spoke of the frictional losses in an electrically-driven cotton mill that he was associated with, due to the lightness of the shafting necessitating pedestals spaced 6ft. apart. Mr. Gass and the President also took part in the discussion.

NEW distant signals with white boards, and electric lights near them, both intended to help the engineman pick up the signals, have, we hear, been placed between Brussels and Antwerp, and are reported to have reduced largely the over-running of signals.

45 BRAKE HORSE-POWER SUCTION GAS ENGINE

CAPEL AND CO., LONDON, ENGINEERS



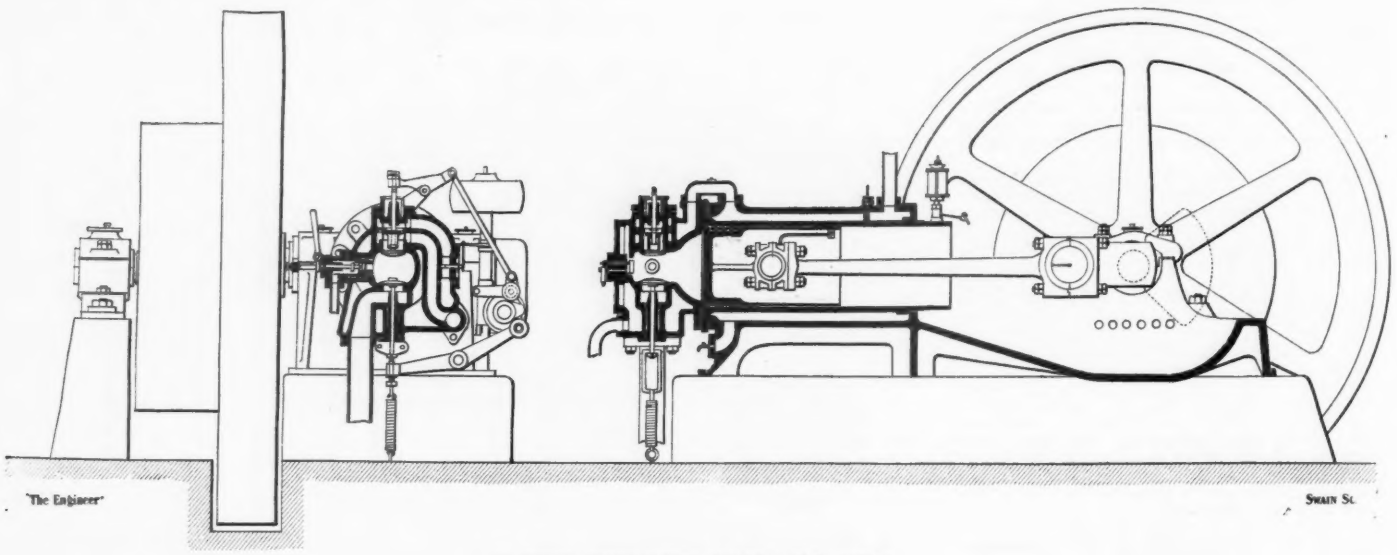
SUCTION GAS ENGINE.

THE larger gas engines designed and manufactured by Messrs. Capel and Co., of 168, Dalston-lane, London, have recently been considerably altered in many of their more important details in order to make them on a par with the best British and foreign design in this class of machinery.

The accompanying engraving shows one of the firm's latest engines, and many of the new features embodied are clearly illustrated. Instead of allowing the cylinder to overhang the bed-plate, it will be seen that the latter is now a large single casting supporting the cylinder, with which the water jacket is cast in one for its whole length. A very good arrangement has been adopted with regard to the liner. This is now so made that the joint between the combustion chamber and water space is dispensed with. The liner is held between the main casting and the breech end by means of a flat flange, and as the other end is quite free to move, it is claimed that no distortion can take place due to expansion. In many engines the joint between the cylinder and breech end has often given trouble, and the elimination of this possible source of mischief is pointed out as a good feature of the engine under consideration. Nothing need be said of the piston, which follows the usual practice, except that it is made particularly long in order to permit of a maximum wearing surface. The crank shaft and connecting-rod are cut from the solid, and are not bent or welded in any way. On the fly-wheel side the crankshaft is extended, and is supported by a third bearing, the pedestal of which, however, is not in any way connected with the bed-plate of the engine. On the other end of the crank shaft is keyed the timing gear for the half-speed shaft, the latter being supported at three places by ring oiled bearings.

The breech end is a special feature of the Capel engine. It carries the valve and ignition gears, and also forms the combustion chamber. At the back of it there is a cover which enables the whole of the water space to be examined and easily cleaned. The valves are arranged in renewable bushes or sleeves, and are opposite to each other. The gas valve is situated above the air valve, and is on the air valve spindle, so that both valves operated together. The air valve opens about one-sixteenth in advance of the gas valve, so that with low lifts—that is, when the engine is running light—the gas valve may not open at all, or, at all events, only occasionally. This arrangement practically constitutes a hit-and-miss device at lower powers, and at higher powers there is a throttle governor. The latter is of the centrifugal type, and is given a large range of speed, which can be adjusted whilst the engine is running. The governing is accomplished by varying the lift of the inlet valve, thus reducing the compression as the load decreases. It is claimed by the makers that this method gives the best results.

Ignition is by magneto, and two sparking plugs are fitted into the cylinder, one at either side. The timing gear is variable, and this also allows a comparatively large range of speed to be obtained. Another feature of the Capel engine is the elaborate precaution taken to ensure efficient lubrication. The cylinder is oiled by a force pump driven by a cam from the cam shaft, the oil being forced on to the piston rings. The gudgeon pin is lubricated separately from the cylinder by means of a wipe contact and tube, a method which is undoubtedly better than relying upon the cylinder oil to find its way to this vital part. The crank pin is oiled by a centrifugal ring fixed to the crank web, the oil being carried to the centre of the pin and then thrown out from the inside of the crank brass. Oiling rings, dipping into oil troughs situated under the bearings, are adopted for lubricating the main and crank shaft bearings.



45 BRAKE HORSE-POWER SUCTION GAS ENGINE

The engine, of which we give an illustration, develops 45 brake horse-power when working on suction gas. On town gas the same engine develops 60 brake horse-power. The former figure is the nominal working load, but a maximum of 52 brake horse-power has been obtained on suction gas. The diameter of the cylinder is 13½in. and stroke 21in., and the above powers were developed at a working speed of 200 revolutions per minute. The engines are well finished, and the care bestowed upon the castings and the general workmanship in construction is particularly noticeable.

THE French Chamber of Commerce, in its annual report just issued, points out that although in view of the general depression the trade between France and the United Kingdom may be considered as fairly satisfactory, nevertheless, there has been a falling-off in the exports from France with regard to a considerable number of articles during the last ten years. The decline is attributed to negligence and carelessness on the part of the French producer in packing and preparing consignments.

SHOP TESTING OF DIRECT AND ALTERNATING-CURRENT MACHINERY.*

By J. W. ROGERS.

IT will be generally admitted that the position occupied by the testing department of an electrical works is an important one, as on it depends the quality and satisfactory performance of the plant turned out. In all modern electrical manufacturing concerns it is the custom to carry out an exhaustive series of "shop" tests to ensure that the machines attain their specified efficiency at various loads and satisfy all other conditions, both electrical and mechanical. The object of a testing department is to supply the engineering department with information which will enable the design of a machine to be checked, and also serve as a guide to its "operating characteristics" when running under working conditions. The shop tests generally carried out on electrical plant may be classified under two distinct heads, viz., experimental and commercial.

Experimental tests are made on all machines of new type for the purpose of obtaining information with reference to their performance under working conditions, and also to compare the actual with the anticipated performance. The tests required for this purpose are those of (1) insulation; (2) rating and efficiency. As is well known, the rating of a machine is determined by (*a*) heating; (*b*) drop in voltage or speed, depending on the machine being a generator or motor; (*c*) commutation; a knowledge of these three quantities being obtained from temperature, regulation and commutation tests respectively, under various conditions of loads. As regards the efficiency this may be obtained (1) from the relation between input and output; (2) by calculation of the copper, iron, friction and windage losses, as determined by the resistance, and iron loss and friction tests respectively.

It is the custom to record the results of the experimental tests carried out on new machines in the form of curves, which are systematically filed for future reference, and then in the subsequent testing of duplicate machines of the same design a few observations only are taken for comparison with these curves, and, if they agree, the machine is passed as up to standard.

Commercial tests are made chiefly to locate faults in manufacture due to defective material, bad workmanship, or faulty assembling. Any defect in the iron circuit of a machine would show up in the saturation and temperature tests in the form of (*a*) excessive iron loss at normal excitation, and (*b*) excessive temperature rise of the iron circuit. Generally speaking, the commercial tests for machines of moderate output are (1) iron loss, saturation, and friction, (2) temperature run at full load, (3) insulation, (4) overload and commutation test.

As already stated, it is generally found that all defects in manufacture are shown up in the temperature test, so that the most important shop tests are those for efficiency and temperature. The time taken by a machine to reach its maximum temperature depends upon its output and design, and as it is impossible to obtain a knowledge of the real efficiency until the C^2R losses reach a constant value, the data from which the efficiency is calculated should always be taken at the conclusion of a temperature test.

As it is impossible to give more than a general outline of the tests carried out by manufacturers in the space at the author's disposal, it will be sufficient to briefly describe the methods of making the various tests and the information to be derived therefrom, dealing first with direct-current machines.

Iron loss, friction and saturation tests of shunt and compound generators and motors.—These tests are most conveniently made by driving the machine to be tested as a generator by belting it to a shunt motor, and measuring the motor input when driving the machine at its rated speed at different voltages. Under these conditions, the total input to the driving motor includes the losses in the motor armature and field + iron loss, brush and bearing friction, and windage in the driven machine. The C^2R loss in the motor armature will vary with the excitation of the machine on test, but the C^2R loss in the motor field may be held constant by heating the field before commencing the test, and keeping the terminal voltage constant. The frictional losses may be considered constant if the speed is held constant throughout the test.

The iron loss and friction test consists in taking readings of the motor input under the following conditions:—(1) No excitation on generator; (2) varying exciting current; (3) no excitation on generator with its brushes raised; (4) belt off, motor running at the normal speed of the machine on test. As a check on the correct position of the brushes, it is the custom to measure the motor input when driving the generator excited to give the normal voltage, but with its brushes raised, and if this reading is subtracted from that representing the motor input when driving generator with same excitation and brushes down, the value of brush friction so obtained should correspond with that found with no excitation on generator. If the values of brush friction do not correspond closely, this proves that currents have been circulating in the armature due to the brushes having been wrongly set. The iron loss in watts for any particular value of exciting current or terminal voltage on the generator is given by:—

Motor input (gen. excited) – motor input (gen. unexcited).

Similarly the friction loss is:—

Motor input (gen. unexcited) – motor input (generator disconnected).

As the same readings are required, a saturation test is generally

* Rugby Engineering Society.

made in connection with the iron loss test. From the results of these tests, an iron loss curve is plotted having watts lost as abscissæ and volts as ordinates, and a saturation curve having field ampères or ampère turns as abscissæ and volts as ordinates.

Iron loss, friction, and saturation tests of series motors.—As the series motor is not a constant speed machine, and the iron loss varies with a change in the speed, it is not advisable to employ the same method as that already described, as it would necessitate a number of tests being made at different speeds. A more satisfactory method consists in running the machine as a motor at different speeds and measuring the input which will represent the energy required to overcome the iron loss, friction and windage for any particular value of speed and field current. Having found the combined losses at different speeds, it is necessary to obtain the friction loss at the same speeds, and from these two sets of readings the iron loss at different speeds may be easily calculated. As the speed of a series motor is very high when run light, it is necessary to shunt the armature by a low resistance, so that the field will carry the larger current and thus reduce the speed which may be varied by altering the shunt resistance. The friction and windage losses may be obtained by running the machine at a low voltage with no shunt across the armature, the voltage being gradually increased to get the same range of speeds as when the combined losses were measured. As the field strength under these conditions will be very small, the iron loss may be neglected, therefore the motor input will be a measure of the friction loss at each speed. From the results of these tests, curves are plotted having iron loss and friction, friction, and main ampères as ordinates, and speed as abscissæ.

Regulation and efficiency tests of generators.—As is well known, the regulation of a generator may be defined as the maximum variation of voltage or current which occurs between "no load" and "full load" under normal working conditions, expressed as a percentage of the normal voltage. Generators may be loaded directly on a rack, or water resistance in the case of machines of moderate output, but it is more economical to employ loading back methods when two similar machines are available. Although the Hopkinson test is too well known to need description here, it may be mentioned that when two compound machines are tested in this manner, the machine which is intended to generate the lower voltage and operate as a motor should have its series windings reversed, if the windings are connected to give a constant voltage when the machine is working as a generator under normal conditions.

The readings taken for a regulation test are:—(1) No load reading, with field rheostat adjusted to give normal volts at no load; (2) full load reading, the diverter, if any, to the series winding in the case of compound machines being adjusted, if necessary, to give the normal voltage, without altering the shunt field rheostat. When taking intermediate readings between no load and full load, all adjustments should remain as when No. 2 reading was taken. The data obtained from this test enables regulation curves to be plotted, having values of terminal volts and shunt field ampères as ordinates, and load ampères abscissæ, the efficiency being worked up from these curves in the following manner, taking the case of a compound generator as an example. The values of terminal volts and shunt field ampères, corresponding to any particular value of external ampères are first read off the regulation curves, the various losses being then calculated separately for that particular load.

The total losses = C^2R losses in armature, series and shunt fields + C^2R loss in brushes + brush friction, bearing friction and windage + iron loss. The C^2R loss in the brushes is given by total ampères × volts drop in brushes, this drop in the case of carbon brushes being taken from a standard curve showing the volts drop at various values of ampères per square inch of brush section for that particular quality of carbon used for the machine on test, the current density in the brushes being calculated from

$$\frac{\text{Total ampères}}{\text{Total brush area}}.$$

It is the custom with some manufacturers to debit the engine with the friction and windages losses in the case of engine type generators, but they are always taken into account in belt-driven machines. The various losses having been separated in the manner described above, the percentage efficiency is given by

$$\frac{\text{Watts output}}{\text{Watts input}} \times 100 = \frac{\text{Terminal volts} \times \text{external ampères} \times 100}{\text{Output} + \text{total losses}}$$

Regulation and efficiency test of motors.—The regulation of a motor represents the change in speed between no load and full load, a regulation test being made by (1) belting the motor to a generator run on water resistance load; (2) loading back on a similar machine; (3) loading on a brake, this being the most direct method of determining the speed regulation of a motor, which, however, can only be carried out on machines of moderate output. The regulation test on a motor is similar to that on a generator, the only difference being that in the case of a motor the speed will be the variable quantity, instead of the terminal voltage as with a generator. The connections for a loading back test are also similar to those required for generators, but when compound motors are tested the series windings should be so connected that their effect is the same in each machine. The readings taken are those of shunt field ampères, armature ampères, speed and terminal voltage, and these results, when plotted with field ampères and speed as ordinates and armature ampères as abscissæ, will represent the regulation speed curve for different loads on the motor under test.

The regulation test of a series motor is made by belting it to a similar machine which is loaded as a generator on a water resistance. The test is started with about 50 per cent. overload, which is gradually reduced, the readings taken being those of terminal volts, field volts, main ampères and speed of the machine on test. As the characteristic of a series motor is such that its speed at any particular load decreases with an increase in the temperature, it is necessary to correct the speeds obtained from the regulation test for a certain standard temperature, which is usually 75 deg. Cent. for enclosed, and 50 deg. Cent. for open-type motors. This correction in speed must be taken into account in working up the efficiency, and may be obtained in the following manner:—The armature and field resistances are first taken at a known temperature, their values at the standard temperature being then calculated. The speed corrected for the standard temperature will then be given by:—

$$\text{Speed from curve} \times \frac{\text{Term. volts} - \text{total drop at standard temp.}}{\text{Term. volts} - \text{total drop at temp. of test}}.$$

The efficiency of motors may be obtained from (1) losses worked up in connection with data taken from the regulation curve, (2) directly from a brake test. When the efficiency is worked up from the losses the values of speed and field ampères corresponding to any particular value of load ampères are read off the regulation curves, the various losses being then calculated in the usual manner. In the case of series motors, the efficiency is worked up from the losses in a similar manner, but the iron, friction, and windage losses must be read off the curves for the corrected values of speed, instead of terminal volts as with shunt and compound machines.

Temperature tests.—The duration of a temperature run and the rise in temperature allowed varies slightly with different makers, but it is the custom to run a machine until the temperature of its various parts becomes stationary. Surface temperatures are taken with mercury thermometers, their readings being checked by calculating the mean temperature rise from the increase in the resistance of the windings. As the resistance of a copper conductor increases by ·428 per cent. per degree C. rise in temperature, the mean temperature rise of the windings is given by—

$$\frac{\text{Hot Resistance} - \text{Cold Resistance}}{\text{Cold Resistance} \times \cdot00428}.$$

Insulation test.—As the insulation of a machine is more liable to break down when hot, this is always made at the conclusion of a temperature run. It consists in applying a high alternating current voltage between the armature and field windings and the frame of a machine. In the case of low voltage machines the testing pressure is generally double the working voltage, but, as the factor of safety of a low voltage winding is higher than that of a high voltage winding, the ratio of the testing to the working voltage should be less for high voltage machines to prevent the possibility of damaging the insulation of the windings. The capacity of the testing transformer used for making dielectric tests is a point which requires due consideration, as it is governed by conditions affecting the testing circuit as well as the apparatus to be tested, and this question may be considered as follows:—In virtue of its static capacity, the apparatus to be tested may be considered as a condenser, the charging current of which may be represented by $C = 2\pi \times 10^{-6} \times V \times N \times K$ (assuming a sine wave of E.M.F. applied to its terminals), where C = current in ampères, V = terminal voltage, N = frequency, and K = capacity in microfarads. It follows, therefore, that the charging current taken by the apparatus to be tested is proportional to its static capacity, and varies directly as the frequency and testing voltage.

The apparent output of the testing transformer would be proportional to the square of the voltage, and may be calculated from the formula given above when the static capacity of the apparatus to be tested is known. The C^2R losses in the insulation are generally very small compared with the charging current, and may, in the majority of cases, be neglected. The dielectric loss has, however, an appreciable effect on the output of the testing transformer when the testing pressure approaches the disruptive strength of the insulation, and as this loss varies directly with the frequency, it should be taken into account when calculating the capacity of a testing transformer to be used for disruptive tests. The frequency of the testing circuit also governs the size of the transformer for a given output, which varies inversely as the frequency. It follows from the above remarks that (1) for a given output the lower the frequency the larger will be the transformer required; (2) for a dielectric test under given conditions the higher the frequency of the testing circuit the larger the capacity of the testing transformer.

An important test coming under the heading of experimental testing which may be mentioned is that known as a distribution or field-form test. It is sometimes made on machines built to a new design for the purpose of determining: (1) the character and strength of the field; (2) the maximum difference of potential between commutator segments; (3) the variation in field strength, and whether it can be improved by altering any constructional details. The machine to be tested is first run light as a separately excited generator, to obtain a potential curve representing the field form with no current in the armature. It is then run on full-load as a generator or motor, as the case may be, at its rated output and speed, to determine the full effect of armature reaction under normal working conditions. The results of a distribution test may be shown graphically by making the horizontal scale represent the distance between the positive and negative brushes, and the vertical scale the volts generated at each point, and a comparison of curves so obtained will plainly show the effect of armature reaction on the field.

Having considered the shop tests it is usual to carry out on direct-current machines, reference will now be made to the testing of alternating current plant.

Alternating-current generators.—The experimental tests carried out on alternators are those for (1) Iron loss saturation and friction; (2) regulation and efficiency; (3) short circuit. As the first test has already been described in connection with the testing of direct-current machines, it will not be considered here. The regulation of an alternator may be defined as the percentage rise in voltage which takes place when full non-inductive load is thrown off, the speed and field current being held constant. The test consists in running the machine at its rated output and speed, with the current in phase with the terminal voltage, a regulation curve showing a varying field charge with a constant terminal voltage. A full-load test can only be made on machines of small output unless two similar machines are available, in which case loading back methods may be employed. A loading back test is made by coupling the alternator shafts together, and also to a direct-current motor of sufficient capacity to supply the power lost in both machines. The efficiency of motor being known, the power supplied may be easily calculated. The two alternator armatures are short-circuited on each other through an ammeter in each phase, the load current being made to circulate between them by weakening the field of one machine, thus causing it to act as a motor and help to drive the other as a generator. The P.F. of the load may be varied by altering the connections between the two armatures, so that there is a phase difference between their E.M.F.'s, and when the relative position of the two armatures is such that their E.M.F.'s are in direct opposition, the power factor will be approximately unity. The efficiency is worked up from the losses in the same manner as with a direct-current generator, the only difference being in the method of calculating the C^2R loss in the armatures of two and three-phase machines.

Short-circuit test.—This is made chiefly to determine the self-induction of the armature, and also the effect of armature impedance in reducing its terminal voltage when the machine is run at constant speed with various values of exciting current. A series of readings is taken connecting the armature current with the exciting current, and from the results of this test a short-circuit characteristic curve may be plotted, which is generally found to be a straight line. The connection between the short-circuit test and the regulation of an alternator may be considered as follows:—When it is impossible to run a machine at full load, its regulation may be calculated from the data given by the open-circuit and short-circuit characteristics, in the following manner. The volts drop due to the armature resistance are calculated for a given load, and added to the terminal voltage on open circuit. The exciting current corresponding to this total voltage is then read off the no-load saturation curve, and its value added vectorially to the value of field current required to give the same load when the armature is short-circuited. The voltage corresponding to this resultant field current is then read off the open-circuit saturation curve, and the difference between this voltage and the terminal voltage expressed as a percentage will represent the regulation of the alternator at that particular load. Perhaps an example of this method of determining the regulation, which is used to great extent in American practice, may be of interest, and the following data refers to a 150-kilowatt three-phase alternator. The total armature resistance of this machine at standard temperature = ·024ω; total ampères = 340; C.R. drop in armature = .024 × 340 = 8.2 volts.

∴ The sum of the terminal volts and C.R. drop = 440 + 8.2 = 448.2 volts.

The exciting current required to give this voltage, as taken from the saturation curve = 42.5 ampères also, the field current required to give 340 ampères on short-circuit = 15 ampères as taken from short-circuit curve. The vector sum of these two values of exciting current = $\sqrt{42.5^2 + 15^2} = 45$ ampères, and the volts corresponding to this resultant field current was shown by the open-circuit saturation curve to have a value = 470 volts.

∴ The regulation at full load with a constant field current = $\frac{470 - 440}{440} \times 100 = 6.8$ per cent.

Commercial tests.—As regards the commercial testing of alternators, the tests generally made are those of:—(1) Polarity, (2) temperature, (3) insulation. With machines of moderate output, the temperature test consists in running the machine on full load, but in the case of large machines it is the custom to run them on open circuit with the field current required to give the normal voltage at full load, this test being followed by a run on short-circuit with the field adjusted to circulate the full load current in the armature.

Induction motors.—The tests generally made on induction motors to determine the iron loss, saturation, efficiency, &c., are those of (1) resistance, (2) saturation, running light, (2) torque locked saturation and impedance, (3) power and slip, and these may be considered separately as follows:—

Saturation tests.—These are made for the purpose of checking the design of the magnetic circuit. The motor is first run light at various voltages, commencing with a voltage about 25 per cent. above the normal, the readings taken being those of ampères per phase, terminal volts and real watts. From the result of this test curves are plotted having total ampères and watts as ordinates and terminal volts as abscissæ. The ampères curve may be compared to the saturation curve of a direct-current machine, and from it the magnetising or no-load current taken by the motor at different voltages may be obtained. Strictly speaking, the magnetising current is slightly less than no-load current, as a certain part of the latter is spent in overcoming the loss due to hysteresis and eddy currents. The primary current taken by an induction motor is the resultant of two components, viz: (1) an energy component which is in phase with the terminal voltage and does useful work; (2) an inductive component, which represents the wattless part of the current, lagging 90 deg. behind the terminal voltage. The apparent input to the motor

$$= \sqrt{\text{energy component}^2 + \text{inductive component}^2},$$

∴ the inductive component

$$= \sqrt{\text{apparent input}^2 - \text{energy component}^2}$$

That is to say, the true magnetising current

$$= \sqrt{\text{total current}^2 - \text{energy current}^2}; \text{ where energy current} = \frac{\text{Real watts}}{\text{Terminal volts}}.$$

The watts curve represents the iron loss and friction at different terminal volts.

The information to be derived from the curves of locked saturation enables the inductive component of the volts, and also the effect of magnetic leakage to be calculated. A knowledge of the starting torque of the motor at different voltages is also obtained from this test, which is made by fixing a brake arm to the shaft, and connecting the motor to the supply circuit in a similar manner to that required for a running saturation test, the torque being measured by means of a scales or spring balance. The motor is supplied with a low voltage, which is gradually increased to its normal value—if the capacity of the generating plant and the design of the motor permits—the readings taken being those of terminal volts, ampères per phase, real watts, and torque. The results of this test may be shown in the form of curves having kilowatts, total ampères, and pounds torque as ordinates and terminal volts as abscissæ. A test sometimes made at the conclusion of the locked saturation is that known as the pulling out or maximum torque test, the voltage at which it is desirable to make it depending upon the output and characteristics of the motor. The resistance of the rotor circuit also has an important bearing on this point, owing to the fact that the pulling out torque is very much greater than the starting torque when the resistance of the rotor circuit is low. It follows, therefore, that the current taken by a large motor to give its pulling out torque at normal voltage is liable to reach an enormous value, and for this reason it is advisable to take the pulling out torque at a voltage considerably below the normal. This test is made by adjusting the voltage to its required value, which must be held constant. The brake is then tightened and balance adjusted on the scales until the motor slows down rapidly without increasing the torque. The actual pulling out point is reached when the motor begins to slow down, at which instant readings of the terminal volts and scales are taken. In connection with the locked saturation test, it is the custom to take two sets of readings of terminal volts, ampères per phase, and true watts, corresponding to the different positions of the rotor with respect to the stator, which give the maximum and minimum values of stator current, the terminal voltage being first adjusted to give the normal full-load current in that winding, and then held constant.

Power and slip curves.—These consist of a series of curves representing the complete performance of a motor. They may be obtained either (1) directly from a brake test in the case of small machines, or (2) by calculation from the losses. The motor is run at various values of torque, representing different loads, its full-load torque being calculated from the output and speed at that point. A complete set of readings covering about 25 per cent. overload is taken at each point, consisting of terminal volts, ampères per phase, true watts, torque, motor and generator speeds. When the power curves are to be worked up from the losses a speed curve is also required, and may be obtained by belting the motor to a generator of sufficient output to give it a 25 per cent. overload, the readings taken being those of motor and generator speeds, terminal volts, and ampères per phase, from which a curve is plotted, having total ampères as abscissæ and speed as ordinates. When a slip indicator is not available, the slip may be calculated from the motor and generator speeds by means of the formula—

$$\% \text{ slip} = \frac{\text{generator speed} - \text{motor speed}}{\text{generator speed}} \times 100.$$

This completes the series of shop tests from which are obtained the data required to work out the true performance of an induction motor.

Synchronous motors.—The experimental tests made on these machines are those of (1) resistance, (2) open and short-circuit characteristics, (3) iron loss, saturation, and friction, (4) efficiency, (5) regulation and V curves. These tests are practically the same as those carried out on alternators, and are conducted in a similar manner, with the exception of those for regulation and V-curves, which may be considered as follows:—As is well known, a synchronous motor may be made to operate at various power factors by altering its field strength, and when the excitation is such that the impressed voltage

$$= \sqrt{(\text{C.E.M.F.}^2 + \text{C.R. drop}^2 + \text{reactive drop}^2)},$$

the armature current will be exactly in phase with it, and the power factor will be practically unity, the current input to the motor being then a minimum. Any further alteration in the exciting current will then give rise to a leading or lagging current, which will cause the current input for any particular load to increase. It follows, therefore, that every load has its corresponding value of excitation which enables the motor to operate with the smallest armature current. This variation of the armature current with the excitation is one of the most important characteristics of a synchronous motor, and the curve representing such variation is, owing to its shape, known as a V curve. The data for these curves are obtained by running the motor on "no load," "half load" and "full load" at different exciting currents, and taking readings of armature and field ampères.

A reference to the curves so obtained will show that the armature current varies to a greater extent, and that the angle of the V is more acute at "no load" than is the case when a motor is loaded, the variation in armature current for any particular value of excitation decreasing as the load increases. There is consequently a wider variation in the power factor for different values of the exciting current when a motor is running light than when loaded. The regulation curve of a synchronous motor shows the relation between the excitation and the armature current at unity power factor. This test is made by belting the machine to a direct-current generator of sufficient output to give it a 25 per cent. overload, and adjusting its excitation so as to obtain unity power factor at all loads. The wave forms of the motor and the supply circuit should be similar, and the terminal voltage and frequency held constant during the test, the readings taken being those of armature and field ampères. The efficiency is

worked up from the data given by the regulation curve so obtained in the same manner as with an alternator.

Rotary converters.—The experimental test carried out on converters are those of:—(1) Iron loss, saturation, and friction; (2) short circuit; (3) efficiency and compounding; (4) commutation.

Iron loss, saturation, and friction.—This test is made in the same manner as with an alternator, but when taking the saturation it is necessary to measure both the alternating and direct-current voltages so that there will be two separate saturation curves from which the average value of the voltage ratio may be calculated by reading off the curves the values of A.C. and D.C. volts for the same value of exciting current.

Short circuit.—This test is made on the direct-current side for the purpose of testing the commutation in a weak field; it also serves as a temperature test in the case of large converters. It is made by belting the machine to a shunt motor and short-circuiting the armature through an ammeter. The converter is then run up to its normal speed with its field separately excited, the excitation being gradually increased until the armature current reaches its full-load value. The readings taken are those of field and armature ampères, which, when plotted, will represent the short-circuit characteristic on the direct-current side of the converter. A short-circuit test on the A.C. side is carried out in a similar manner, the readings taken being those of armature and field ampères, and kilowatts, the short-circuit characteristic being represented by curves having armature ampères as abscissæ, and field ampères and kilowatts as ordinates.

Compounding and efficiency.—A compounding test, which is really a form of regulation test, is made to show the relation between the kilowatts output and the terminal voltage on the direct-current side, and the most satisfactory method of making this test is to run the machine with a constant field strength, so that the generator voltage will increase with the load current. The efficiency of a converter may be obtained (1) directly from a full-load test; (2) by calculation from the losses. The first method consists in running the machine on full load at unity power factor, and measuring the A.C. input and D.C. output, the efficiency being the ratio of these two quantities. When the efficiency is worked up from the losses, these are calculated for different outputs on the direct-current side, the efficiency being given by—

$$\frac{\text{Output}}{\text{Output + losses}}$$

The copper loss in a converter armature is calculated for values of equivalent currents, and not the load current, as is the case with a direct-current generator.

The commercial tests made on converters are those of—(1) Polarity; (2) synchronising; (3) temperature; (4) insulation.

Synchronising.—The object of this test is to obtain data showing the conditions under which a converter may be synchronised with the line when started up from its A.C. side. Before starting the test the brushes on the D.C. side should be set on the neutral position, and the voltage and current required to start the starting motor should be taken with the shunt field of the converter open, so that the friction loss may be calculated. When the exact moment of synchronism is reached as indicated by the synchronising arrangement used for this test, readings are taken of the shunt-field current, D.C. voltage, and terminal voltage on the starting motor, this data serving as a guide to the operation of synchronising the converter.

Temperature and insulation tests.—A temperature run on full load is only possible with machines of moderate output, and in the case of large machines they are run short-circuited on the D.C. side with the field separately excited to give the full-load armature current. This test is followed by running the machine self-excited on open circuit, the exciting current being about 25 per cent. above its normal value. The insulation test for converters generally consists in applying an alternating voltage equal to double the working voltage between the armature, field windings, and the frame of a machine.

Motor generator sets.—It is the custom to carry out the usual experimental and commercial tests on each machine separately when the set is the first built to a new design, the combination being then run on full load either directly or by loading back when two similar sets are available. In conclusion, the author has attempted to give a general description of the tests it is customary to carry out in modern testing shops, and although the subject treated will be familiar ground to many members of this Society, it will, it is hoped, be at least of interest to some.

THE INSTITUTION OF CIVIL ENGINEERS.

MARINE PROPULSION BY ELECTRIC MOTORS.

AT the ordinary meeting on Tuesday, the 7th December, Mr. James Charles Inglis, President, in the chair, the paper read was "Marine Propulsion by Electric Motors," by H. A. Mavor, M. Inst. C.E. The following is an abstract of the paper:—A comparative study of the methods of applying power on land to the propulsion of vehicles and other purposes, and of the methods adopted at sea, shows that, while the problems have much in common, there are differences in methods and in experimental results which have mutually interacted from time to time between land and sea practice, tending towards assimilation, with a gradual improvement in the economic results in both cases.

At first sight it would appear that on a ship the direct connection between the power generator and the propeller renders unnecessary the use of any intermediate transmission device, and so long as reciprocating steam engines were the best attainable power generators it was possible to correlate the speeds of generator and propeller so as to gain the best efficiency of each. The steam turbine and the non-reversible internal combustion engine introduce a new set of conditions. On land the turbine holds the field for the largest powers, and because its speed of revolution is unsuited to ordinary mechanical direct application of power for industrial purposes, its evolution has been directly associated with electrical transmission. These turbines are many of them of the same order of magnitude as the turbines used on shipboard, and therefore a comparison of economy in the two conditions is inevitable.

Before the introduction of electric transmission the marine engineer had the more complete scientific data, and consequently the marine engine held the blue ribbon of economy which now belongs to the turbo-electric generator. Among the reasons for the higher efficiency of the land turbines are:—That the engineer on land is freer than is the marine engineer to adopt a suitable speed of revolution; that the land turbine runs at approximately constant speed for all loads, and can therefore be run on the governor, rendering easier the application of superheat and augmented vacuum; that on land it is possible to subdivide the power-units to meet the conditions of varying load, and thus maintain at the smaller loads an efficiency not materially different from the efficiency at the full load of the system; that at sea change of power is directly associated with change of speed, and the whole of the power-units must always be in motion while the ship is in motion. The same engine has to run the ship at 10 knots and at 20 knots, although the power varies very widely between those limits. Also the high economy on land of power-production associated with electric transmission is largely due to the possibility of exact measurement of power under all conditions of load, giving a complete knowlege of the effect of all changes in the apparatus or in the methods of working it.

The proposition here made is to provide an electric equipment intermediate between the prime mover and the propeller, extending the limits of practical economy in each by modifying the restrictions which the prime mover and propeller impose upon one another, and providing that the prime mover may operate at or near the constant speed required for the attainment of maximum efficiency and full power, and that the power expended in driving machinery not required for work is reduced to a minimum or entirely eliminated. At full power all the elements of the generating plant are in full operation and the whole power resources can be concentrated on driving the ship. When full power is not required the generating plant may be shut down in sections. To accomplish these ends special motors have been designed, which give the necessary changes of speed and direction and permit of the advantageous combination or elimination of the power generators. These motors involve no new electrical principle, but simply mechanical adaptation of well-known electric designs. Alternating current alone is available for the purpose in question, and normal motors have therefore a fixed speed of rotation which is a simple multiple of the generator speed.

Two methods of speed change are proposed each associated with a new form of motor. The principle of operation of the "Spinner" motor is that an ordinary normal motor driving the propeller at a fixed speed, with the shaft and propeller directly connected, is so arranged as to be rotatable as a whole about the propeller-shaft axis. This rotation is accomplished by a second motor concentrically arranged outside the first, so that the main motor system may be rotated in either direction—again at a fixed speed which is a simple multiple of the generator speed—and the speed of rotation of the propeller-shaft and of the propeller in the water is the algebraic sum of the rotation of the main motor and of the rotation imposed upon it by the auxiliary motor. As both motors are reversible it will be seen that in each direction there are three speeds:—(1) The speed of the main motor system—the middle speed; (2) the speed of the main motor system minus the speed of the auxiliary motor system—the low speed; (3) the speed of the main motor system plus the speed of the auxiliary motor system—the full speed. The combination may be designed for any three-speed ratios, such as 1, 2, 3; 2, 3, 4, &c. Any intermediate speeds required are attainable by adjustment to the turbine or engine governor, which can be operated economically through a range down to about 75 per cent. of full speed. The same method is applicable to non-reversible internal-combustion engines.

The "Multiple" motor is an ordinary squirrel-cage induction motor in all respects, except that its stator is wound with two or more independent electric circuits each associated with a separate source of supply of energy. For example, the motor may be fed from two sources of supply at 25 and 50 periods respectively, the motor windings being for 46 and 92 poles. At full power and speed both windings are in operation under their most advantageous conditions; each of these windings results in a synchronous speed of 66 revolutions per minute. When the 25-period current is supplied to the 92-pole winding the speed is 33 revolutions per minute. Either of these motors permits of one or more generators being used together in the same mechanical system without electrical connections or synchronising devices.

The author then goes on to discuss the application of electric propulsion to certain definite types of ship, and also gives diagrams illustrating the saving in space obtained. The examples worked out are as follows:—(1) In a cargo vessel of 840 shaft horse-power the normal reciprocating engine equipment with a single screw would weigh 570 tons for engines, boiler, and fuel. The electrical equipment, consisting of three oil engines, three motors, and three propellers, would weigh only 270 tons, including fuel. Further, with coal at 20s. per ton and oil at 40s. per ton, the saving in fuel cost on a total of £17 would be £5 6s. per day at full power. (2) In a similar cargo vessel gas engines might be used. Taking an equipment of 770 shaft horse-power, and using three gas engines and one multiple motor, the respective weights of the normal and proposed equipments would be 446 tons and 229 tons. The consumption of fuel shows an equally favourable comparison. (3) A third cargo vessel, but of 1030 shaft horse-power, is worked out for the purpose of illustrating the application of steam turbines to the multiple motor. One plant drives the ship under normal conditions; extra power is supplied by a small turbo-generator, and is used to keep up the ship's speed in heavy or contrary weather. (4) On a passenger vessel of, say, 16,200 shaft horse-power, the electrical equipment permits of a sub-division of the plant, so that at ship speeds lower than the maximum only part may be run, and that at full power. The advantage is gained without loss in full power economy, and without additional complication.

PASS LIST (*Interim*), OCTOBER EXAMINATIONS, 1909.

Studentship (69).—C. J. Allen, A. C. E. Anthony, J. T. Aslin, A. J. B. Atkinson, W. Barrington, J. H. Berry, E. Black, E. A. Black, F. T. Blythe, C. W. Boyle, R. W. Brims, J. Brooks, T. E. Brydon, A. M. S. Burn, F. J. Burns, P. F. Campbell, W. H. A. Chester, G. A. Clark, F. H. Colebrook, W. R. Cooper, A. S. Culham, J. T. Currie, B. N. Dutta, E. J. E. Everett, K. B. Findlay, L. E. Garbutt, G. Glanville, T. C. Gray, T. R. Hancock, A. C. Harland, B. A. E. Heilig, F. E. Henson, W. A. Hine, C. R. Hollingsworth, H. S. Hornby, H. Y. Hsu, G. G. Jackson, G. F. C. Jonas, E. C. Last, C. V. M. Lewis, A. McColgan, D. R. Mackie, J. A. Manners-Smith, F. W. Meyer, L. W. Nott, F. E. Oakes, A. C. V. Orrell, C. R. Otto, G. N. Parker, W. E. Parker, R. D. Patterson, K. N. Pearson, C. A. Phillips, H. A. Rhodes, H. W. Richards, L. E. Sawyer, R. A. Shiell, W. L. Siddle, P. B. Smith, R. F. Speir, E. L. Stainbank, G. K. Sutherland, T. J. Taplin, jun., J. C. L. Train, R. B. Walker, L. G. Walters, E. C. Whelan, J. H. Wiles, F. S. Wilkinson.

Associate Membership: Candidates Examined in London (195): *Whole Examination* (99).—M. K. Ahmed, C. V. Albrecht, W. G. Anglesea, H. F. Anns, W. K. Bartley, E. L. Bascombe, B. H. Bayliss, J. Beer, C. S. Berry, H. H. Bird, E. H. Bond, N. E. Brooks, A. E. Brounger, A. G. Brown, P. C. Burnett, E. L. W. Byrne, S. J. N. Carrington, S. F. R. Carter, R. A. M. Cecil, A. Cooper, H. W. B. Cotterill, J. F. Craig, H. B. Dart, E. A. H. Daw, C. E. Dickinson, H. M. Dunkerley, H. M. Edmunds, G. E. Edson, E. A. Evans, R. Foster-Palmer, D. W. Gollan, C. Gorman, K. D. D. Grazebrook, L. W. K. Greiff, A. E. Griffiths, K. B. Griffith-Williams, W. E. R. Gurney, H. L. Guy, A. D. Harrison, A. J. Hart, C. E. Harvey, J. L. Hodgson, S. J. Hunter, A. G. Ingham, W. Jaggar, D. Kennedy, W. H. Kirby, A. S. Knox, J. S. Laing, R. W. Landon, B. R. Leapingwell, W. S. Lloyd, G. O. Lockwood, A. N. Lucey, T. S. Malik, R. H. May, W. E. W. Millington, A. S. F. Mody, W. H. Morgan, N. Murray, R. Nelson, P. G. Norman, S. J. Norton, W. J. Norton, E. A. Oliver, J. A. Orrell, H. B. Parrott, A. S. Parsons, J. K. Partridge, V. N. ff. Powell, R. C. Pratt, H. Raj, G. E. Rhodes, E. M. Rice, L. H. Richards, H. Robbins, F. Round, G. K. Rouquette, U. S. Row, T. R. Sewell, C. D. Sheldon, M. Sinclair, A. Slater, C. Smith, S. W. Smith, H. H. M. Spink, E. S. Stanford, A. F. V. Stephenson, A. C. B. Taylor, J. A. Taylor, L. G. Tessier, H. Thackeray, A. W. Thomas, J. T. V. Twest, M. Wilks, P. D. Wilson, T. W. Wishlade, M. Wynne-Jones, S. Yates.

Section B of Part II. (48): *Previously passed in Part I. and Section A of Part II.*—H. A. Alexander, F. A. Atkinson, G. R. Atkinson, R. G. Bartholomew, G. S. Baxter, M. N. Bowmer, J. S. Bullough, V. C. D. B. Carpenter, H. F. Coales, G. Cooper, H. A. Cox, G. K. Dalal, H. Dyson, P. N. Fawcett, D. Furness, J. R. Gill, T. C. F. Greenway, J. S. Guthrie, A. G. Haigh, S. St. G. Harvey, F. Horspool, W. P. Hulton, S. J. Kirby, K. M. Kirkhope, R. C. Y. Kirkpatrick, T. F. Linnell, R. W. Lister, F. T. Murray, W. W. Newman, L. F. W. Nolan, E. G. Parker, P. I. Payne, C. A. Pollock, J. W. Revell, R. W. Richardson, B. R. Saberwal, J. H. Samuel-Yates, J. G. Scoular, J. Scruby, P. K. Shinde, C. V. Stephens, H. Taylor, J. C. Telford, G. G. Terrell, P. Trump, R. A. Wallace, E. G. Woodward, A. Young.

Part I. and Section A of Part II. (48):—E. S. R. Adams, J. G. Ambrose, E. J. Attenborough, C. G. H. Bellamy, A. W. Brayshay, J. Broadhead, H. P. Clarke, C. A. Dickinson, P. C. D. Douglass, B. P. Ellis, J. Ferguson, D. C. Fletcher, H. F. Fox, A. Gidley, C. Glenday, R. W. Ham, H. Hamer, W. Houghton, T. H. Leader, G. M. Lemboke, A. E. Loach, W. G. McFadyen, D. N. Macpherson, A. S. Marr, I. Meerza, E. A. Mills, J. R. Moreton, E. Morgan, J. Mulcahy, P. F. Murphy, L. Napier, A. L. Ohlson, A. G. B. Palmer, C. St. L. Perfect, V. C. Peycke, A. C. Pratt, H. D. Roberts, S. D. Shroff, S. Simaika, J. M. Simpson, E. L. Sladen, J. R. Smith, N. Smith, V. F. Stephens, A. C. Thomson, F. D. Tunnicliffe, B. N. Weekes, A. E. Wheatley.

AUSTRALIAN NOTES.

(From our own Correspondent.)

Queensland Railways.

FROM the report of the Queensland Railway Commissioner for the year ended June 30th last, the following information is obtained:—During the year 138½ miles of new line have been opened for traffic, and a further 376 miles are under construction, which are expected to be opened in the course of a few months. As in some of the other Australian States, there is a strong cry for the duplication of the existing lines to cope with the ever-increasing traffic, and it is intended to ask Parliament for a vote of £100,000 to be spent next year in providing duplications for these railways. The revenue shows satisfactory increases in all branches over the previous year, as under:—

	£	
Coaching traffic	55,721	increase
Minerals traffic	2,969	,,
Agricultural produce	8,124	,,
Wool	23,016	,,
General merchandise	20,408	,,
Live stock	42,000	,,

Working expenses show an increase of £173,362, the principal increase being £71,946 on maintenance of way and works. It involves the cost of relaying. A number of composite lavatory coaches have been added to the branch lines, and fitted with electric light. Fifteen carriages of special design are now in course of construction in the railway workshops, and are intended for the Sydney mail trains.

Results of working, compared with the corresponding period of the previous year, are as follows:—

	Year ended June, 1909.	Year ended June, 1908.
Capital cost of construction £	23,396,322	22,575,603
Length of line, miles	3,497½	3,350
Average miles open for the year	3,444	3,230
Goods earnings £	2,103,119	1,960,881
Working expenses £	1,227,098	1,053,736
Net earnings £	876,021	8 7.145
Working expenses to gross revenue, per cent.	58.35	54.01
Train miles	7,391,332	6,557,723
Tonnage carried (exclusive of live stock), tons	2,483,413	2,425,529
Locomotives, number	428	368
Carriages, number	495	474
Goods stock, number	8,581	8,095
Brake vans, number	131	120

South Australian Railways.

The best indication of the prosperity or decline of the business of a country is the comparative results of the railways. This is exemplified in the case of the South Australian railways—the report of the Commissioner for the year ended June 30th last having now been published. In consequence of the prolonged strike at Broken Hill and the suspension of operations at the mines, the total receipts of the Barrier traffic showed a decrease of £198,653. The decrease in minerals carried, compared with the previous year, was 180,583 tons. There was a gratifying increase in the tonnage of wheat carried, and the consequent result was an increase in the receipts under this item of £25,353, and in live stock showing an increase of £20,188. An average distance of 123.42 miles was run for all the goods and live stock, as compared with 120.73 miles for the previous year. On June 12th last Mr. A. G. Pendleton, C.M.G., retired from the position of Railway Commissioner, after being connected with the railways of that State for thirty-two years, during the first eighteen years of which he occupied the position of General Traffic Manager, and the last fourteen years as Railways Commissioner. The position of Railways Commissioner has been filled by Mr. A. B. Monorieff, who was formerly the Chief Engineer to those railways.

	Year ended June 30th, 1908.	Year ended June 30th, 1909.
Miles open at close of year, 3ft. 6in. gauge	1,280	1,283½
,, ,, 5ft. 3in. gauge	599½	599½
Average miles open for the year	1,860½	1,861½
Capital cost on miles open £	13,909,635	14,157,245
Average cost per mile open £	7,4.2	7,498
Gross earnings £	1,741,259	1,639,259
Working expenses £	969,530	940,828
Net earnings £	771,729	698,431
Working expenses to gross earnings, per cent.	55.68	57.39
Net earnings to capital cost, per cent.	5.57	4.93
Passenger journeys, number	12,839,428	13,854,588
Goods and live stock, tons	2,255,996	2,165,619
Train miles	5,010,121	4,925,356
Gross earnings per train mile	6s. 11.41d.	6s. 7.88d.
Working expenses per train mile	3s. 10.44d.	3s. 9.84d.
Gross earnings per average mile open £	936	871
Working expenses per average mile open £	521	500
Locomotives, number	351	337
Coaching vehicles, number	443	465
Goods and live stock vehicles, number	6,226	6,384
Ton-miles (goods and live stock)	272,373,487	267,271,137
Average miles per ton	120.73	123.42
Average earnings per ton per mile d.	1.04	0.95

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—The third general meeting of the session will be held in the Lecture Theatre of the Literary and Philosophical Society, Westgate-road, Newcastle-upon-Tyne, this evening, at 7.30 p.m. Members of Council will meet in the Institution Rooms, Bolbec Hall, at 7.15 p.m. The discussion on Mr. D. Myles's paper on "Notes on Marine Boiler Design, Construction and Economy," will be resumed. There will be a discussion on Mr. T. O. Handy's paper on "Some Notes on the Erection of the Baikal Railway Ferry Steamers," and a paper on "The Remarkable Failure of a Consignment of Steel Ship Plates," by Mr. W. J. B. Wilson, will be read.

STEAM TURBINES FOR MARINE WORK.—A paper was recently read before the Liverpool Engineering Society by Mr. C. J. Blackburn, entitled "The Working of Parsons Steam Turbines on Fast Channel Steamers," from which it appears that the total number of mercantile steamers running with Parsons turbines is sixty-nine, with a total horse-power of 606,000, and of these twenty-three were Channel steamers, aggregating 193,000 horse-power. The total number of war vessels built and under construction is 194, representing a total horse-power of 2,700,000. The total number of all vessels built and under construction at the present time with these turbines is about 275, representing about 3½ million horse-power. With regard to manœuvring power, Mr. Blackburn said he had carefully timed the Ben-my-Chree when leaving the pier at Douglas, Isle of Man, and the average length of time occupied in leaving the end of the pier, bringing the vessel to a state of rest, and getting a headway on her was usually four minutes, but the manœuvre had been done in two and a-quarter minutes. For a vessel 375ft. long, 46ft. beam, and with a displacement of 3350 tons, the author considers this a very satisfactory performance.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(*From our own Correspondent.*)

A Busy Trade.

THE only branch of the finished iron trade in which there is a steady activity of demand, and in which sellers seem to be masters of the price position, is that engaged in galvanised iron. Local producers of this material keep fully employed, with good prospects of a continuance of present very gratifying conditions in 1910. Good shipments are being made, and most of the Midland makers have as much work on hand as they can cope with for the time being. Values are steady at £11 to £11 5s. f.o.b. Liverpool for 24 w.g. material. There is rather less irregularity, too, than recently in the black sheet iron trade, which supplies the raw material for the galvanisers, but it has to be recorded that the developments of the past few years, which have resulted in the establishing of large new competitive works in South Wales, Monmouthshire, and the North of England, have weakened the position of the South Staffordshire local makers fundamentally. Quotations locally rule on the basis of £7 to £7 2s. 6d. for sheets of 20 w.g., £7 2s. 6d. to £7 5s. for 24 w.g., and £7 15s. to £7 17s. 6d. for 27 and 28 w.g.

The Bar Iron Trade.

Little that is satisfactory can be reported about the bar iron trade. The Staffordshire marked bar business rules steady alike as to demand and price, values being well sustained on the basis of £8 for best sorts and £7 for second-grade sorts, with £8 12s. 6d. as the quotation for the L.W.R.O. brand of iron. Respecting second and third-class irons, however, known respectively as "unmarked" and common bars, the report is the reverse of prosperous. According to the accounts brought to 'Change this (Thursday) afternoon, in Birmingham values are still on the down grade, and there seems nothing to stop them. The prices of "unmarked" or merchant iron are falling almost continually—the outcome of a famine in demand, and common bar quotations are being forced down by continued Belgian importations.

Unremunerative Prices.

Prices are now at an almost unremunerative level. Indeed, one firm of common bar makers distinctly asserted to-day that they had booked orders at 5s. per ton loss purely to keep the ironworkers employed. Unmarked bars were easily obtainable at £5 16s. 3d. to £5 17s. 6d., delivered Birmingham, and hurdle and bolt iron for early delivery was said to have been done at as low as £5 12s. 6d. per ton. Even for delivery over the first quarter of 1910 only a small advance on this figure can be got, and sales are spoken of over next April at £5 15s. per ton—truly an exceedingly lean figure.

Steel Trade Improving.

Steel billets and sections are undoubtedly developing a stronger market position. Present requirements show little variation. It is unquestionable as regards forward buying that sellers are putting the brake on very firmly. Contracts have been made up to March at current rates, but beyond that neither raw nor finished steel producers are disposed to commit themselves. This uncompromising attitude has a hardening effect upon the market, though quotations can hardly be said to be quotably influenced. Current prices are:—Bessemer sheet bars, £4 15s.; Siemens sheet bars, £4 17s. 6d.; angles, £5 17s. 6d. to £6; girder plates, £6 to £6 2s. 6d.; boiler plates, £7 5s.; joists, £5 15s. to £6; mild bars, £6 7s. 6d. to £6 17s. 6d.

Raw Iron Values.

The rather better state of the raw iron market reported last week, as it affects forward business for delivery into, say, the second quarter of 1910, is preserved. Coke continues firm, which is the main occasion of the strength in pig iron, and dearer fuel is generally looked for next year, alike coke and coal. Pig iron makers are, therefore, a little cautious, and prices are also assisted by the knowledge that some blast furnaces both in the Staffordshire district and in the Midland raw iron centres are being blown out. Quotations are:—Forge pig iron: Staffordshire common, 45s. to 46s.; part-mine, 48s. to 49s; best all-mine forge, 85s.; foundry, 90s.; cold blast, 115s.; Northamptonshire, 47s. to 48s.; Derbyshire, 48s. to 49s.; North Staffordshire forge, 50s. to 51s. 6d.; best, 58s. to 59s.

NOTES FROM LANCASHIRE.

(*From our own Correspondent.*)

MANCHESTER, Thursday.

Better Inquiry for Pig Iron.

THERE was a shade better feeling in pig iron on our Exchange on Tuesday. There was certainly more inquiry for delivery over next year, but the position is very uncertain, makers not being inclined to commit themselves, while buyers, on the other hand, are not disposed to make purchases beyond the month of March. Demand on shipping account both to Germany and the United States has also had a tendency to stiffen the market, especially for Middlesbrough brands. There are, however, re-sale lots of Lincolnshire on the market, which are offering at fully 1s. 6d. per ton under makers' list prices. Hematite is steady, and the tendency is decidedly upward in character.

Finished Iron and Steel.

Spot business is slow. Billets, however, continue scarce, and practically there are no foreign lots being offered.

Copper, Lead, Tin.

Copper: Sheets were reduced 20s. per ton, but tough ingot was dearer. Lead: Sheets slightly higher. Tin: English ingots firmer.

Quotations.

Lincolnshire No. 3 foundry, 54s. 6d.; Staffordshire, 53s.; Derbyshire, 55s.; Middlesbrough, open brands, 59s. 7d. to 59s. 10d. Scotch: Gartsherrie, 61s; Glengarnock, 60s.; Eglinton, 59s. 6d., delivered Manchester. West Coast hematite, 61s. to 61s. 6d.; East Coast ditto, 60s. 6d., both f.o.t. Delivered Heysham: Gartsherrie, 59s.; Glengarnock, 58s.; Eglinton, 57s. 6d. Delivered Preston: Gartsherrie, 60s.; Glengarnock, 59s.; Eglinton, 58s. 6d. Finished iron: Bars, £6 10s.; hoops, £7 12s. 6d.; sheets, £7 12s. 6d. to £7 17s. 6d. Steel: Bars, £6 2s. 6d. to £6 5s.; Lancashire hoops, £7 5s.; Staffordshire ditto, £6 17s. 6d. to £7; sheets, £7 17s. 6d. to £8; boiler plates, £7 5s. to £7 7s. 6d.; plates for tank, girder, and bridge work, £6 5s. to £6 7s. 6d.; English billets, £4 12s. 6d. to £4 15s.; foreign ditto, nominal; cold drawn steel, £9 5s. to £9 10s. Copper: Sheets, £73; tough ingot, £63 10s.; best selected, £63 10s. Copper tubes, 8¾d.; brass tubes, 7¼d.; condenser. 8¼d.; rolled brass, 6½d.; brass wire, 6¾d.; brass turning rods, 6¾d.; yellow metal, 6⅛d. to 6⅜d. per lb. Sheet lead, £17 per ton. English tin ingots, £146 10s. to £147 per ton.

The Lancashire Coal Trade.

The attendance on our local Coal Exchange was about an average one, but business generally was disappointing. Although the weather created a "spurt" in house coal, this has fallen away again, and for the time of the year the demand is much below the average. Slack and furnace coal is rather in buyers' favour, and inquiry is slow. On the other hand, shipping and bunkering coal is fairly good, although low prices have to be accepted to induce business.

BARROW-IN-FURNESS, Thursday.

Hematites.

There is a rather better demand for hematite iron this week, and it is evident there will soon be a turn in the market for the better. The inquiry at the moment is mainly for forward delivery in the early months of next year, and makers are also doing some prompt trade. They are producing a considerable tonnage of iron, practically all of which is going into delivery. There are twenty-nine furnaces in blast. The difficulty between the Distington Ironworks and their men has been amicably settled, and the men have resumed work, while the two furnaces which were damped down have been restarted. Prices are steadier, and mixed Bessemer numbers are now at 62s. 6d. net f.o.b., while warrant iron sellers are at 61s. net cash, buyers 6d. less. The trade doing in special hematite iron is very satisfactory, and it is recognised when trade improves there will be a marked improvement in the demand for the higher-graded qualities of metal, which it is found can be produced to almost any specification according to the requirements of the consumers. This class of iron is selling at about 65s. per ton. Charcoal iron is also in large demand, and arrangements have been made by the accumulation of a large amount of charcoal from the neighbouring district to keep the only furnace in England producing charcoal iron in blast for a long time to come. Ferro-manganese is in good request, and good deliveries are being made alike to home and foreign consumers. Spiegeleisen is in steady demand not only on home but on foreign account. Sales of scrap iron are being made in large parcels, and there is a good demand for the best sorts of metal. Iron ore is in rather fuller request, and prices this week are at 12s., 14s. 6d. and 18s. per ton net at mines. Sales are mostly of the better quality. The imports of foreign ore are smaller than they have been, but good supplies for forward delivery in the New Year have already been purchased.

Steel.

The demand for steel rails has improved of late, and makers are generally engaged on light sections. There are only two of the three mills in this district at work at present, and this position is likely to be continued for a few weeks yet, although orders are to hand which would justify a full output. Prices rule at about £5 5s. per ton net f.o.b. The demand for merchant steel is quiet, but a good trade has lately been done in hoops and in strips for the armouring of electric cables. A poor report is given of the shipbuilding material trade, but this is expected to improve with a revival in shipbuilding.

Shipbuilding and Engineering.

Much better hopes are being formed as to the future of the shipbuilding trade, and the prospect is that before long the firm of Vickers, Sons and Maxim will be very busy on large contracts for the home Government, and possibly for foreign governments as well.

Shipping and Coal.

The exports of iron and steel from West Coast ports last week were 6690 tons—iron 1694 tons and steel 4996 tons—as against 11,858 tons for the corresponding week of last year—a decrease of 5168 tons. For the year to date the shipments aggregate 591,728 tons, against 480,370 tons for the corresponding period of last year—an increase of 111,358 tons. Coal steady.

THE SHEFFIELD DISTRICT.

(*From our own Correspondent.*)

Steam Coal Firmer.

A STRONGER tone pervades the hard coal market, owing in part to the good demand for shipment, and extra supplies ordered to tide over the approaching holidays. The return of coal business with Hull exhibits a heavy advance on the month and on the year so far. Since the report was issued, the export trade from Hull has continued to keep up well, the weight for the first week in December showing a total of 61,350 tons, as compared with 39,635 tons for the corresponding week of last year. Rotterdam was the largest customer in that week, taking 8848 tons, Rouen coming next with 5215 tons.

Railway Coal Contracts.

No further progress has been made in the settlement of the locomotive fuel contracts with the railway companies. The offer of the coalowners was at 9s. 3d. per ton, which is an advance of 9d. per ton on last year's rates. The companies for the present are receiving deliveries under running contracts, which are somewhat in arrears.

House Coal—A Steady Business.

The demand for domestic fuel keeps fairly brisk, merchants at local depôts reporting rather more active trade. There are practically no stocks in hand. The weight being forwarded to London and the South, as well as to the Eastern Counties' markets, is fully up to the normal amount. Consumers' requirements generally are stimulated by the approaching holidays. The weather has again taken a milder turn, diminishing the prospect of any further advance this year. Quotations are not changed, best Barnsley making 12s. 6d. to 14s. per ton, and secondary descriptions from 10s. 6d. to 11s. 6d. per ton. In the coalfield generally from four to five days a week are being worked.

Small Coal and Coke.

The short time being worked in the Lancashire cotton trade has not appreciably affected the demand for the South Yorkshire coal used in these mills, as well as in the Yorkshire textile trades. All orders for coal now being received are more or less urgent, as is usual at this season of the year. This remark applies to every quality of coal. The higher qualities of slacks have been in active demand for a considerable time, and there is now more doing in the secondary sorts. The grades of South Yorkshire smalls used in the cotton and woollen industries continue firm at from 4s. 6d. to 5s. 6d. per ton. Furnace coke is at present rather firmer than when last reported, more inquiries coming forward. Quotations continue as before:—Best washed, 12s. 6d. to 13s. per ton; unwashed, 11s. 6d. to 12s. per ton.

The Iron Market: Hematite Firmer.

Hematites, both West and East Coast, are firmer in tone than for some weeks past. No material business is being done, but the hopeful feeling entertained for the New Year is making producers stand out for better prices for forward delivery; while, on the other hand, consumers having only scant order books are not eager to purchase beyond present requirements. The Lincolnshire Ironmasters' Association held their customary meeting last Friday, and, as we anticipated, made no alteration in prices. Derbyshire irons are also unchanged. Quotations:—Hematites: West Coast, 68s. to 70s. per ton: East Coast, 65s. to 67s. per ton. Lincolnshire: No. 3 foundry, 52s. 6d. per ton; No. 4 foundry, 51s. 6d. per ton; No. 4 forge, 51s. 6d. per ton; No. 5 forge, mottled and white, 51s. 6d. per ton; basic, 52s. 6d. per ton. Derbyshire: No. 3 foundry, 52s. per ton; No. 4 forge 50s. 6d. per ton. All quotations net, and for delivery in Sheffield and Rotherham.

Bars, Hoops, and Sheets.

The South Yorkshire Bar Iron Association, at their recent monthly meeting, made no change in the quotation. The depression in the bar iron business continues as marked as ever. Bars, £6 10s. per ton; hoops, £7 10s. per ton; sheets, £8 10s. per ton.

Swedish Iron.

Satisfaction is expressed in this district at the termination of the strike in Sweden. This strike, however, has not been entirely unanimous for some time past, supplies of iron having been obtainable for pressing requirements all along. Still, in view of the hopeful feeling of improved trade, many orders given by Sheffield firms to Swedish makers will now have attention, and better work is expected in several local firms engaged specially in this branch of the iron trade.

Sheffield and the French Tariff.

The Council of the Sheffield Chamber of Commerce met on Monday. The present position of affairs with regard to the French tariff was reported to the Council, and it was pointed out that the unsatisfactory proposal to classify steel in accordance with its chemical contents has been carried through the Chamber of Deputies. It was further pointed out that the duty on steels containing more than a small percentage of tungsten or chromium is raised from 15f. to 50f. per 100 kilos. This duty is regarded by the Council as likely seriously to injure the trade from Sheffield to France, if not entirely, to arrest the trade in the higher-grade steels. The duty on engineers' tools is raised from 22f. to 150f. per 100 kilos., and this duty the Chamber regarded as being prohibitive to nearly every article in this class. The matter was referred again to the Tariff Committee.

NORTH OF ENGLAND.

(*From our own Correspondent.*)

Cleveland Pig Iron.

AN improvement in tone and actual business can be reported this week in the Cleveland pig iron market, and the rather depressed feeling which was apparent last week has given place to one of cheerfulness. Holders of iron are less keen to sell, and consumers have during the last few days bought rather more freely than hitherto this month. The reduction of the Bank rate has to some extent relieved the strain on the operators in warrants, and there is not that pressure to clear out which was noticeable last week, especially as almost everyone is again taking a more sanguine view of the prospects for next year. Well-known business men publicly predict that trade will next year show a considerable improvement on that of the current year, though they do not expect it will be more than fair; and as for prices they are not likely to be materially above those now ruling. As soon as the elections are out of the way it is believed a brisker market all round will be reported. Speculators are thus inclined to hold on, and that the fluctuations of late have been within such narrow limits would indicate that the bulk of the warrant iron now lodged in Connal's public stores is in strong hands. London houses are known to hold a good deal of the warrant iron, and they are as firm in regard to prices as the makers themselves. Business this week in No. 3 Cleveland G.M.B. pig iron for prompt f.o.b. delivery has been mostly done at 50s. 3d.; while for No. 1 the rate has been 52s. 6d.; No. 4 foundry, 48s. 9d.; No. 4 forge, 48s. 6d.; and mottled and white, 48s. per ton. For delivery over the first quarter of 1910 fully 1s. per ton more than the prompt prices have to be paid, and the premium over prompt figures for the second quarter is 1s. 6d. per ton.

Hematite Pig Iron.

The position of East Coast hematite pig iron makers continues good, and prospects are encouraging now that the revival in the shipbuilding industry is so strong. The cheap lots of hematite iron that have lately been offering by second hands have either been sold or taken off the market; at any rate, they are not in evidence now, and the market is stronger in consequence. Mixed numbers are not at present to be had under 60s. per ton for prompt delivery, and consumers are more ready to buy. Some fair orders were given out by Sheffield consumers a fortnight ago, and this week several well-known Sheffield manufacturers have been in this district. American consumers have also considerable quantities of East Coast hematite pig iron coming due to them. The quotation for mixed numbers of hematite for delivery over next quarter is firm at 62s. 6d., and for the second quarter at 65s., and certainly higher prices have become necessary, seeing how rapidly the cost of materials is increasing. For some time the nominal quotation of Rubio ore delivered c.i.f. Middlesbrough has been 17s. 6d. per ton for prompt delivery, but this week it has risen to 18s. 6d. per ton, and 18s. 3d. has been paid, while 19s. 4½d. has been paid for 20,000 tons delivered at Stockton over the first half of the year, which is equal to 19s. 3d. Middlesbrough. A marked advance was generally expected, taking into account the heavy demand for Rubio ore that is reported, not only from this district, but also from Germany and the United States. Coke is also rising in price; the sellers are holding off for 17s. 6d. per ton for early deliveries of furnace coke delivered equal to Middlesbrough, and it is thus as dear as foundry coke, yet some of the manufacturers affirm that they can do better by selling the coal as coal instead of converting it into coke. There is no doubt that coke is relatively dearer than Cleveland pig iron at the present time, so that cheaper rates for the latter can hardly be expected.

Manufactured Iron and Steel.

The prospects of business in the steel trade are very favourable; the leading firms are fairly well supplied with orders, and the output is on a larger scale than it has been at any time since 1907. The best demand is for rails, plates, angles, sheets—both black and galvanised—and hoops, but it appears difficult to keep the bar mills in regular operation. It has been expected that the manufacturers would before this have advanced the quotations for plates, angles, and sheets, but as yet they have not seen their way to make any such change. There can be no doubt that the situation is more satisfactory, and consumers must expect soon to be called upon to pay more for their requirements. Iron and steel ship plates are strong at £6, steel ship angles at £5 7s. 6d., iron ship angles at £7, steel bars at £6, iron bars at £7, steel hoops at £6 5s., steel strip at £6 2s. 6d., steel sheets—singles—at £7 5s., steel joists £5 15s. to £6 5s., all less 2½ per cent. f.o.t. Heavy steel rails are quoted at £5 5s. net f.o.b. The Darlington Forge Company, Limited, Darlington, have this week despatched to Messrs. Harland and Wolff, Belfast, the stern frame, rudder, and brackets for the new White Star liner Titanic. They weighed 280 tons, or 60 tons more than those for the Mauretania and Lusitania, which were also constructed at the same works. The consignment had to be sent by rail from Darlington to West Hartlepool on Sunday, when there was no other traffic, and then it was forwarded by sea.

Shipbuilding and Engineering.

Improvement is reported in the engineering industry, but it may be said that most establishments are turning out a good deal less than they were last year, and the output will be a good deal less than it was in the record year 1907. The co-partnery scheme established in connection with Irvine's Shipbuilding and Dry Dock Company, Limited, West Hartlepool, at the suggestion

of Sir Christopher Furness, has been attended with very satisfactory results. The employé shareholders are informed that they are from every point of view very satisfactory. At the two yards nine steamers have been launched, and orders for six more steamers are on hand. Under the new conditions of employment operations at the shipyards have proceeded with comfort to all concerned. The financial results are highly satisfactory, and enable the directors to make a distribution on the agreed basis of the scheme, viz., the guaranteed 4 per cent. to the employé shareholders; the fixed 5 per cent. to the ordinary shareholders, with a bonus of 5 per cent. to both classes of shareholders. Thus the employé shareholders will get 9 per cent. per annum, and the ordinary shareholders 10 per cent. per annum. The report suggests that the scheme, which has been nine months in operation, should now be put upon a permanent basis as a preliminary to tendering for other important work.

Coal and Coke.

There is considerable improvement in the coal trade, and consumers are buying more freely, now that it is recognised that the application of the Mines Eight Hours Act on January 1st will not be attended by any trouble. The employers' and the men's representatives have made arrangements as to how the pits shall be worked, and it is practically decided that the three-shift system shall be introduced. For prompt delivery best Northumberland steam coal is at 11s. 6d. per ton f.o.b., but 11s. will be taken for January delivery. More demand is reported for gas and bunker coals, the best qualities of the former realising 11s. to 11s. 3d. per ton f.o.b., and bunkers range from 9s. 9d. to 10s. 3d. per ton f.o.b. Tyne Dock. Furnace coke is strong at 17s. 6d. per ton delivered at the Middlesbrough furnaces, and the demand for it is fully equal to the present production.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

The General Business Outlook.

THE impression appears to be gaining ground that trade is really improving. Christmas holidays and the unsettling tendency of the approaching general election may postpone the further development of business for a time, but the indications of expansion in various directions are so manifest that belief in the coming better time is everywhere in evidence. Shipbuilders have received a considerable accession of new orders within the last two or three weeks, and inquiries seem to point to additional business of this description being soon available. A decided revival has been gradually taking place in the freight market. The United States have recently taken up a large amount of British tonnage on time charter for Transatlantic, West Indian, and River Plate trades This is an immediate relief to the freight market, and the business in other directions has expanded in such a way as to promise not merely the maintenance of present rates of freight, but a probable advance in various sections of the market. It is confidently anticipated, from orders already fixed and inquiries received, that we shall do an extensive trade in iron and steel goods with Canada in the coming year. Important developments are also expected in South Africa and the Australian Colonies, which are expected materially to assist business at home. These are a few of the subjects now engaging attention, and leading to the hopeful state of feeling that prevails.

The Iron Market.

There has been some weakness in the warrant market since last report, and the business done has been materially less than last week. The near approach of the holidays is believed to be adversely affecting speculative dealing at the moment. Business has been done in Cleveland warrants from 50s. 7d. to 50s. 1d. cash, 51s. to 50s. 3½d. one month, and 51s. 7d. to 51s. three months. Sales have also been made at 50s. 5d. for delivery in twenty-one days, 50s. 9d. twenty-six days, and 51s. 9d. for February 28th. The demand for hematite warrants has not issued in any substantial extension of the business that took place last week.

Scotch Makers' Iron.

The business in Scotch iron for delivery during the remainder of the year has been of small consequence, but merchants and makers are reported to have entered into good contracts over the early months of next year, these including very considerable shipments to Canada. The inquiries for special brands on English account have also been encouraging. Prices of Scotch iron have been well maintained, notwithstanding the depression in warrants. Free at ship in Glasgow harbour, Monkland, No. 1, is quoted 57s.; No. 3, 55s.; Carnbroe, No. 1, 59s. 6d.; No. 3, 56s. 6d.; Clyde, No. 1, 62s.; No. 3, 57s.; Gartsherrie, and Calder, Nos. 1, 62s. 6d.; Nos. 3, 57s. 6d.; Summerlee, No. 1, 63s.; No. 3, 58s.; Langloan, No. 1, 64s.; No. 3, 59s.; Coltness, No. 1, 85s.; No. 3, 58s.; Eglinton, at Ardrossan or Troon, No. 1, 58s.; No. 3, 56s.; Glengarnock, at Ardrossan, No. 1, 64s.; No. 3, 59s.; Dalmellington, at Ayr, No. 1, 61s.; No. 3, 56s.; Shotts, at Leith, No. 1, 62s. 6d.; No. 3, 57s; Carron, at Grangemouth, No. 1, 64s.; No. 3, 58s. per ton. Since last report two additional furnaces have been put on ordinary iron, while one has been withdrawn from hematite. There are now 84 furnaces in operation in Scotland, compared with 83 last week, and 77 at this time last year, and of the total 42 are producing hematite, 37 ordinary, and 5 basic iron.

The Hematite Trade.

The arrivals of hematite ore in the Clyde in the course of the week numbered thirteen cargoes, and the harbour authorities and railway companies are now giving fair despatch from the vessels to the iron and steel works. So far as can be ascertained, the current output of hematite pig iron is considerably larger than the rate of consumption. One furnace less is now employed on this class of iron than a week ago. The market demand for hematite is poor, but steady deliveries are being made to local consumers under existing contracts. Merchants quote Scotch hematite 63s. per ton for delivery at the West of Scotland steel works.

Pig Iron Shipments.

The shipments of pig iron from Scottish ports in the past week were small, amounting to only 3859 tons, compared with 6589 in the corresponding week of last year. To the United States only 30 tons were despatched, and nothing was sent to either Canada, South America, Italy, Holland, or Russia. India took 25 tons, Australia 280, France 10, Germany 120, Belgium 50, other countries 230, the coastwise shipments being 3094 tons, against 2562 in the corresponding week. The arrivals at Grangemouth of pig iron from Cleveland and district amounted to 9473 tons, compared with 10,771 in the corresponding week of 1908.

Finished Iron and Steel.

The malleable iron trade remains depressed, with works partly idle, and quotations for export are exceptionally low. In the steel trade the inquiry for structural material for export is poor. A good shipping business is being done in thin sheets. The home demand for steel has not turned out so well as was expected, and it now appears likely that few additional orders will be available until after the holidays. The inquiry for boiler plates for shipment as well as for home use is fairly active.

The Coal Trade.

There has been a good business in shipping coal since last report, and the recent advances in prices are so far maintained. At Glasgow Harbour all coal is quoted for shipment 10s. 6d. to 10s. 9d., steam coal 10s. to 10s. 6d., and splint 10s. 9d. to 11s. per ton. House coal for home use is firm, and in active request owing to cold weather. The question of the rate of wages to be paid the colliers has been this week submitted to arbitration at meetings in Edinburgh under the chairmanship of Lord Balfour of Burleigh, and an adjournment took place in order that evidence might be produced as to the prices obtained by the coalmasters. Both parties are pledged to abide by his lordship's decision, so that no serious trouble is apprehended.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Last Week's Coal Trade.

STORMY weather again affected tonnage arrivals, but fortunately there was no great loss of shipping, as reported last week. The chief result was to hamper business seriously, and to some extent affect quotations. On the whole, there was not much change in prices, but a few of the leading coalowners were much inclined to advance quotations for January shipment, showing that in their opinion the New Year will bring about an improvement. One satisfactory piece of news discussed on 'Change was the placing of Admiralty orders confirming the opinion of a leading coalowner that they were certain to be received. "Welsh coal was indispensable."

The Admiralty Orders.

Only the old coalowners remember the excitement at Cardiff when, chiefly through the efforts of Messrs. Fothergill and Vivian, a share of the orders was secured for Cardiff. Now the trade has grown so enormously that their non arrival this year, though regrettable, was not looked upon as a calamity. They came to hand on Tuesday, but, as usual, quantities and prices were kept as secret as possible; but it is understood that practically the whole of their requirements, totalling from 1¼ to 1½ million tons, have been placed. Next week I hope to obtain some definite facts. One authority states that for best steam prices range up to 16s. 3d.; another, usually well informed, states that the figures are for best 15s. 6d. to 16s. net, and for second-class down to 14s. 9d. Cardiff colliery owners have received the bulk, though the placing covers a wide area. Latest:—A very good undertone. It is said on 'Change that one result of the better outlook is that some agents have withdrawn quotations they had given for next year. Best steam coal, 16s. 3d. to 16s. 6d.; seconds, 15s. 6d. to 16s.; ordinaries, 14s. 6d. to 15s.; best drys, 16s. 3d. to 16s. 9d.; ordinary drys, 14s. 6d. to 15s.; best washed nuts, 13s. to 13s. 6d.; seconds, 12s. 6d. to 13s.; best washed peas, 12s. to 12s. 6d.; seconds, 10s. to 11s. 6d.; very best smalls, 8s. 9d. to 9s. 3d.; best ordinaries, 7s. 9d. to 8s 3d.; cargo smalls, 6s. 9d. to 7s. 6d.; inferiors, 6s. to 6s. 6d.; very best Monmouthshire black vein, 15s. 3d. to 15s. 6d.; ordinary Western Valleys, 14s. 6d. to 14s. 9d.; best Eastern Valleys, 13s. 9d. to 14s.; seconds, 13s. to 13s. 3d. Bituminous: Very best households, 17s. to 18s.; best ordinaries, 15s. to 16s.; No. 3 Rhondda, 17s. 3d. to 17s. 6d.; brush, 13s. 6d. to 13s. 9d.; smalls, 10s. to 10s. 6d.; No. 2 Rhondda, 13s. to 13s. 3d.; through, 9s. 6d. to 10s.; smalls, 7s. to 7s. 6d. Patent fuel, 15s. to 15s. 6d. Coke: Special foundry, 24s. to 27s. 6d.; foundry, 19s. to 20s.; furnace, 17s. to 17s. 6d.; pitwood, 19s. 3d. to 19s. 9d.

Newport, Mon., Coal.

With the arrival of long-delayed tonnage, merchants have now for several days been busy in reducing stocks. General tone steady. Not so much fresh business as expected. Fair business done up to holidays. Latest:—Best black vein, large, 15s. to 15s. 3d.; Western Valleys, 14s. 3d. to 14s. 6d.; Eastern Valleys, 13s. 6d. to 13s. 9d.; other sorts, 12s. 6d. to 13s. 3d.; best smalls, 7s. to 7s. 3d.; seconds, 6s. 3d. to 6s. 9d.; inferiors, 5s. 9d. to 6s. 3d. Bituminous coal: Best house, 15s. to 15s. 6d.; seconds, 14s. to 14s. 6d. Patent fuel, 15s. to 15s. 3d. Coke: Foundry, 18s. to 19s.; furnace, 17s. to 17s. 6d. Pitwood, 19s. 6d. to 20s.

Swansea Coal.

Anthracite steady; good undertone. Brisk demand for Swansea Valley and other brands. Last prices well maintained. Machine coals firm; rubbly culm strong demand; scarce. Latest: Best malting, 23s to 24s. net; seconds, 21s. to 22s. net; big vein, large, 17s. 6d. to 19s., less 2½; red vein, 12s. 6d. to 13s. 6d., less 2½; machine-made cobbles, 23s. to 24s. net; Paris nuts, 25s. 6d. to 26s. net; French nuts, 26s. to 28s. net; German nuts, 25s. to 26s. net; beans, 18s. 6d. to 19s. 6d. net; machine-made large peas, 11s. to 12s. 6d. net; fine peas, 10s. 6d. to 11s. net; rubbly culm, 5s. 6d. to 6s., less 2½; duff, 2s. 6d. to 3s. net. Steam coal: Best large, 17s. to 18s.; seconds, 14s. 6d. to 15s.; bunkers, 9s. 6d. to 10s. 6d.; small, 7s. to 9s., all less 2½. Bituminous coal: No. 3 Rhondda, 18s. to 18s. 6d.; through, 14s. 9d. to 15s. 6d.; small, 10s. 3d. to 10s. 6d. Patent fuel, 13s. to 13s. 6d., all less 2½. Coal quotations all f.o.b., net cash 30 days.

Port Talbot.

This port had a fairly good week, though, like others on the seaboard, it suffered from the long-continued tempestuous weather. The imports included a large quantity of pig iron and copper ore, and in coastwise exports a large total of slag. In all, the total shipments were over 40,000 tons.

Iron and Steel.

Latest prices in pig iron and steel bar at Swansea:—Pig iron: Hematite, mixed numbers, 60s. 6d. cash and month; Middlesbrough, 50s. cash, 50s. 6d. month; Scotch, 50s. 3d. cash and month; Welsh hematite, 66s. to 67s. 6d. delivered; East Coast hematite, 64s. to 65s. c.i.f. Steel bars: Siemens, £4 15s. to £4 17s. 6d.; Bessemer, £4 15s. Iron ore, 16s. 6d. to 17s., Newport and Cardiff.

Tin-plate.

The quantity of tin-plates received from works last week totalled 104,137 boxes, shipments 77,973 boxes, and stocks now remaining at Swansea total 114,334 boxes. It is evident that Welsh plates are in growing favour in the East, for the shipments to that quarter last week, it was stated before the Trust, was the largest yet despatched. Market continues firm, and prices have advanced correspondingly to the improvement taking place in tin. It is reported in the Swansea district that a large quantity of bookings have been made for the first months of the New Year by the leading oil companies. The demand from the Pacific Coast, and from American buyers, is said to have been large, and in some quarters quite unexpected. Latest prices: Ordinary Bessemer and Siemens tin-plates, 12s. 6d. to 12s. 7½d.; ternes, 22s. to 22s. 3d.; wasters, usual terms. C A. roofing sheets, £8 10s. to £8 15s.; big sheets for galvanising, £8 10s. per ton; finished black plates £9 10s. to £9 15s.; galvanised sheets, M.G., £11 to £11 5s. per ton; block tin, £148 12s. 6d. Other quotations, Metal Exchange, Swansea: Copper, £60 5s. cash to £61 5s. three months; lead, English, £13 12s. 6d.; Spanish, £13 2s. 6d.; spelter, £23 1s. 3d.; silver 2 1/16 per oz.

The Swansea New Dock and Harbour Trade.

But for the downpour, the new dock business, satisfactory as it was, would have been larger. At the Harbour Trust meeting last week the Chairman reported an increase on last month of 57,000 tons. Among the items of increase pig iron figured as 10,000 tons. In the exports coal, coke, and patent fuel were 26,000 tons; tin plates and galvanised sheets, 8000 tons over corresponding month.

AMERICAN NOTES

(From our own Correspondent.)

NEW YORK, December 8th.

QUITE a number of manufacturers of finished iron and steel products are being offered more business for winter and spring delivery than they are able or willing to take. Some of the demand is due to the apprehension of buyers that a further advance in prices may be made in January. There will be very little ground for such an advance, because most manufacturers who have to buy pig iron and crude steel are assured that prices will remain where they are. Besides, it is generally understood that the active preparations in progress for increased production in raw and semi-finished material will constitute an ample protection against speculative values. The largest buyers of material at the present time are shipbuilders and bridge builders. The shipbuilders began some three weeks ago to order liberally, and they are still being heard from on account of the new ship work that is coming to hand. Outside of these two sources the demand has fallen off this week, and the larger interests do not anticipate a revival of the buying movement until after the holidays. The only exception to the anticipated quiet is found among the buyers of sheets and tin-plates. Sheet steel and wire also are under fair inquiry, but as the sheet steel companies are far over-sold the new business that is offered is not promptly accepted. The greatest demand has been for blue annealed sheets. The lake ore season closes this week. All of the furnaces depending on that source of supply are well provided for for the winter. Steel plate is far over-sold to steel car makers, and new business is in sight which will extend the engagements of the plate mills far into spring.

Four new furnaces will be in blast by February on the Ohio River, ten miles below Pittsburgh, which is the site of the new mill to be erected by Jones and Laughlins. The mill will be an aggregation of mills for the manufacture of rods, wire, nails, tin-plate, rails and structural material. Advices from all steel centres in the south are of a highly encouraging nature. Some rumours are afloat regarding very large investments of capital in Alabama. Copper has fallen in price slightly. The exports for the week ending December 2nd were 5862 tons. Exports last Friday, 1700 tons. The outlook for copper is said to be satisfactory to the copper interests, but in view of the large European holdings the volume of future exports is uncertain. Tin is quiet and prices irregular. Lead is selling steadily at unchanged prices.

LAUNCHES AND TRIAL TRIPS.

PIKEPOOL, steel screw steamer; built by Ropner and Sons, Limited; dimensions, 358ft. 6in. by 50ft. 10in. by 25ft. 6in.; engines, triple-expansion, pressure 180 lb.; constructed by Blair and Co.; launch, November 26th.

RENARD, torpedo boat destroyer; built by Cammell, Laird and Co.; to the order of the Admiralty; dimensions, 266ft. by 28ft. by 16ft. 7½in.; launch, November 30th.

NETHER PARK, steel screw steamer; built by the Northumberland Shipbuilding Company, Limited; to the order of John Greenlees and Co., of Glasgow; dimensions, 395ft. by 49ft. 9in. by 29ft.; to carry 7300 tons; engines, triple-expansion, 24½in., 40in., 68in. by 48in. stroke, pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company; trial trip, recently.

POSTE IRO, steel screw steamer; built by Sir W. G. Armstrong, Whitworth and Co.; to the order of Pile and Co., of London; dimensions, 285ft. by 43ft. 6in. by 17ft. 6in.; engines, triple-expansion, 15in., 25in., 41in. by 27in. stroke; constructed by Richardsons, Westgarth and Co.; trial trip, recently.

CITY OF COLOMBO, steel screw steamer; built by Swan, Hunter and Wigham Richardson, Limited; to the order of the Ellerman Lines, Limited; dimensions, 437ft. 9in. by 54ft. by 33ft. 7in.; to carry 9880 tons; engines, triple-expansion, 25½in., 43½in., 75in. by 51in. stroke; constructed by the Wallsend Slipway and Engineering Company, Limited; trial trip, December 1st.

LIVORNO, steel screw steamer; built by Earle's Shipbuilding and Engineering Company, Limited; to the order of T. Wilson, Sons and Co., Limited; dimensions, 300ft. by 42ft. 6in. by 20ft.; launch, December 2nd.

BOVERTON, steel screw steamer; built by the Tyne Iron Shipbuilding Company; to the order of Evan Thomas Radcliffe and Co., of Cardiff; dimensions, 341ft. by 48ft. by 24ft. 4½in.; engines, 24in., 40in., 65in. by 42in. stroke, pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company, Limited; launch, December 7th.

ROCHESTER CITY, steel screw steamer; built by Sir Raylton Dixon and Co., Limited; to the order of Mr. W. A. Watson, of Sunderland; dimensions, 240ft. by 35ft. 3in. by 17ft. 6in.; engines, triple-expansion, 17½in., 29in., 47in. by 33in. stroke; pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company; launch, December 9th.

CONSTANTINE, steel screw steamer; built by the Blyth Shipbuilding and Dry Docks, Limited; to the order of J. Ridley, Son and Tulley, of Newcastle-on-Tyne; dimensions, 245ft. by 36ft. 9in. beam; engines, triple-expansion, 19in., 31in., 51in. by 36in. stroke, pressure 180 lb.; constructed by the North-Eastern Marine Engineering Company; trial trip, recently.

PRINCE RUPERT, twin-screw passenger steamer; built by Swan, Hunter and Wigham Richardson; to the order of the Grand Trunk Pacific Railway Company of Canada; dimensions, 320ft. by 42ft. 2in. by 18ft.; engines, triple-expansion; constructed by the Wallsend Slipway and Engineering Company, Limited; launch, December 13th.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. W. NOBLE TWELVETREES, M.I. Mech. E., A.M.I.E.E., &c., whose address until recently was 91, Louisville Road, Tooting, S.W., has removed to 195, Bedford-hill, S.W.

THE Adnil Electric Company, Limited, of Adnil Buildings, Artillery-lane, London, E.C., informs us that it has appointed Mr. James Turnbull, of 3, New-street, Birmingham, its agent for the whole of the Birmingham district, including the counties of Warwickshire, Worcestershire, Shropshire, and Staffordshire.

THE A.E.G. (Allgemeine Elektricitäts Gesellschaft) of Berlin has disposed of its English installation, engineering, and consumers' business to a new firm called A.E.G. Electric Company, Limited, with offices at 121, 123, and 125, Charing Cross-road, London; Cardiff, Glasgow, Manchester, Newcastle-on-Tyne, and Sheffield.

CONTRACTS.—Boulton and Paul, Limited, of Norwich, have secured the contract for the supply of twelve bungalows for use during the construction of the Benguella Railway extension, West Coast of Africa.—Among the recent orders obtained by Applebys Limited are those for a 100-ton overhead traveller for Yorkshire, a 60-ton overhead traveller for Spain, a 30-ton overhead traveller for Spain, five 65ft. portable Temperley transporters for coaling purposes, two 60ft. portable Temperley transporters for Brazil, and a Temperley fixed transporter for Yorkshire.

NOTES FROM GERMANY, FRANCE, BELGIUM, &c.

(From our own Correspondent.)

Rheinland-Westphalia.

No change worth speaking of has taken place on the iron market since last week; in a few instances only have prices been raised, and there is more confidence generally. The Steel Convention has resolved to reduce export bounties for semi-finished steel to M. 10 p.t. for the second quarter in 1910; for the first quarter the former bounty of M. 15 p.t. will continue. The Heavy Plate Convention, at a meeting in Cologne on the 26th November, was prolonged till April 1910. This Convention has also been extended so as to include plates for shipbuilding. The Union of Rhenish-Westphalian Hoop Mills has resolved to maintain the prices now ruling, viz, M. 127.50 to M. 132.50 p.t., free Cologne or Dortmund, for the next few weeks. At a meeting on the 9th inst. the Bar Convention was prolonged for another year; prices for the second quarter in 1910 have been fixed at M. 106 p.t. free Neumkirchen, and M. 110 p.t. free Oberhausen. The Prussian Railway Administration has placed orders for 492 locomotives, worth over 30 million marks, with various North and West German works for delivery from April 1st to September 30th, 1910. On the Düsseldorf Change on the 3rd inst. prices were further raised as follows:—Basic from M. 49 to M. 52 and M. 54 p.t.; Luxemburg forge pig from M. 47 to M. 49 p.t.; German foundry pig No. 3 from M. 58 and M. 60 to M. 59 and M. 61; Luxemburg foundry pig from M. 51 and M. 52 to M. 52 and M. 53 p.t.; hoops from M. 125 and M. 130 to M. 127.50 and M. 132.50 p.t.; sheets from M. 125 and M. 130 to M. 127 and M. 131 p.t.

Improvement in Coal.

Demand and inquiry have been increasing on the Rhenish-Westphalian coal market, and the accounts given of the Silesian coal trade are likewise satisfactory.

Austria-Hungary.

Weakness has been the characteristic feature of the iron and steel market during the last few weeks. October was disappointingly quiet, and the business in November has been even more limited, so that the returns for the last quarter of this year will be unfavourable. In bars and in rails a falling off against previous months will be felt, and though dealers have been inclined to purchase more freely now, on account of the new tariff that will come into force on the 1st of January, the general business in iron and steel remains very limited. Want of wagons in the Ostrau-Karwin district has become quite a calamity, for the demand of late has been extremely active, so that the pits, in a number of instances, have been unable to supply requirements within the time stipulated for. Brown coal is in strong request in the Bohemian district, and a rise in demand is anticipated.

Increasing Activity in France.

During the last two months employment in the various branches of the iron industry has steadily improved, and rates have been slowly moving upwards. Employment in the crude iron business is strong, and the manufactured iron industry will be well engaged all through next year in consequence of the extensive orders given out by the French Railway Administration. Up to the present 2280 wagons are known to have been ordered, Diétrich in Luneville and the Société Franco-Belge being the chief producers. Large purchases of marine requirements are also to be made; there is talk of seven armoured cruisers of 22 600 tons each to be delivered within three to four years. In the Haute-Marne and in the Loire district employment on the finished iron market has been so strong that prices have been advanced 5f. p.t. for hoops and plates, and bars in iron and steel will probably also meet with a similar advance. In the north girders have been very well inquired for, the Paris market proving a good customer. Pipe foundries and wire mills are satisfactorily employed; the rise of 10f. p.t. for wire speaks well for the condition of this branch of business. In the Meurthe-et-Moselle Departement the basis quotation for bars rose from 165f. to 170f. p.t. The works in the Champagne quote 180f. p.t. for merchant iron No. 2 and for common sorts of steel bars, while best sorts fetch 185f. p.t., sheets standing at 200f. to 220f. p.t.

The Belgian Iron Trade.

In bars a slight falling off in demand was felt all through last week, but until now producers have been able to maintain the prices formerly quoted. The terms of delivery are comparatively long, and the mills do not care to commit themselves beyond the 1st of January. For home consumption the price of 135f. to 145f. p.t. is maintained. Heavy plates are neglected, while sheets and medium sorts move on satisfactorily. Girders are inclined to move upwards, although this is the dull season for these articles. A good deal of firmness has been shown in rails; only in exceptional cases have they gone down below £5 4s. f.o.b. Antwerp. So far as prices are concerned, firmness has increased on the pig iron market. For the first two quarters rates have been fixed at 63f. p.t. for forge pig, 67f. to 68f. for basic, and 68f. p.t. for foundry pig, free place of consumption. This is exactly what was quoted in April and May, before foreign competition caused prices to fluctuate. Scrap iron is extremely depressed. Semi-finished steel has moved from 80f. to 82f. in consequence of a lively demand from abroad. Orders come in rather slowly at the construction shops, as, even at reduced prices, contracts are difficult to obtain.

SMART WORK.—A smart piece of engineering work has recently been performed by Bull's Metal and Melloid Company, Limited, Yoker. The Allan liner Grampian recently required a new bronze blade, but only four days could be allowed to complete the work. The pattern was received by the firm on a Tuesday at 3 p.m., and by 3 a.m. on the following Saturday the heavy blade was completed ready for the boss. The work naturally included the moulding of the blade, drying the mould, pouring, cooling, detaching the dead-head, removing 3½ cwt. of metal in turning, facing, drilling and stopping out centre, as well as finishing of edges and dressing the surfaces. Six hours were lost by small accidents and stoppages. It is believed that this repair easily breaks all records of the same kind. In order to execute repairs to bronze propellers in the most expeditious and careful manner, the company has fitted a furnace sufficiently large to give room for the whole propeller blade up to the flange or boss. The blade under repair is slowly brought up to a red heat in this furnace, and thereafter straightened and formed to correct shape and pitch by squeezing, wedging, or screwing, without hammering.

LECTURES ON AERONAUTICS AT THE IMPERIAL COLLEGE.—Arrangements have been made by the Governors of the Imperial College of Science and Technology for a series of short courses of lectures on problems connected with the general subject of aeronautics and for the award of scholarships to qualified students desirous of undertaking research work in scientific problems connected with aeronautics. The first of three courses will begin about the middle of January next, in which Sir George Greenhill, formerly Professor of Mathematics in the Ordnance College, Woolwich, will treat of "The Dynamics of an Aeroplane." In the early part of February, Mr. H. R. A. Mallock will begin to deal with "Fluid Resistance," and after Easter Colonel H. C. L. Holden, head of the Royal Gun and Carriage Factories at Woolwich, will take up the subject of "Light Petrol Motors for Aerial Work." The research Scholarships are to be tenable for one year at the Imperial College, and in suitable cases provision may be made for part of the work to be undertaken at the National Physical Laboratory. Scholars will be entitled to free admission to the College, and to a maintenance allowance varying with the circumstances of the individual.

BRITISH PATENT SPECIFICATIONS.

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 3d. each.

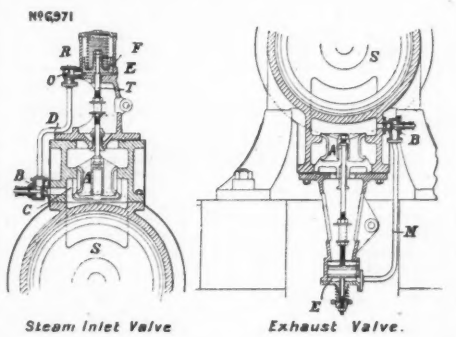
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-office of opposition to the grant of a Patent.

STEAM ENGINES.

6971. March 23rd, 1909.—IMPROVEMENTS IN OR CONNECTED WITH DROP VALVE REVERSING ENGINES, William Thomas Bell, of the firm of Robey and Co., Limited, Globe Works, Lincoln, and Arthur John Wood Graham, of the same address.

This invention relates to automatic release over-pressure valves fitted to drop valve reversing engines, to provide for a quick release in case of the steam pressure becoming excessive in the steam cylinders. For the purpose of the invention as fitted to the steam inlet valve A, in addition to the usual relief valves, another valve B is fitted to the steam space C of the cylinder, *i.e.*, that portion of the steam which is in communication with the piston. This additional valve B is fitted with a spring of sufficient strength to resist the ordinary working pressure of the cylinder. Should, however, this pressure suddenly increase, due to all the inlet and outlet valves being closed at the time, this valve B will open and

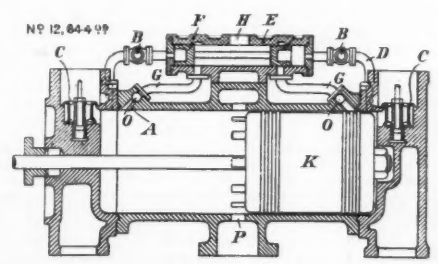


Steam Inlet Valve *Exhaust Valve.*

the steam will then pass up a pipe D into the cylinder E, which will force up the spring-controlled piston F which is connected to the steam valve A through a spindle T. This operation will instantly release the excessive pressure in the cylinder S, and so avoid any damage being done to the engine. Also, in order that the cylinder E above referred to may be used in the usual way to cushion the steam valve on its seat, a non-return valve O is fitted which has also fitted the usual screw adjustment at R for regulating the air cushion. When this automatic release over-pressure valve is fitted to the exhaust valve A—see right-hand engraving—the arrangement is substantially the same as for the steam inlet valve, except that the steam from the additional valve B passes down a pipe M instead of up, and enters at the opposite end of the cylinder E to force the piston F inwards, and so raise the exhaust valve A, to which it is connected by a spindle.—*November 24th*, 1909.

12,644. December 2nd, 1908.—IMPROVEMENTS IN AND RELATING TO STEAM ENGINES, *Johann Stumpf, of* 33, *Kurfürstendamm, Berlin.*

This invention relates to engines in which the exhaust takes place through ports in the centre of the cylinder which are covered and uncovered by the piston at the end of its stroke. The object of the invention is to provide means by which the high compression pressure may be relieved during starting. During starting the cocks B are opened. When the steam is passed through one of the main steam valves, C for instance, the high-pressure steam passes into the cylinder and also through the pipe D to the casing E. The valve F is in consequence pressed to the left, so that the left-hand exhaust port G is uncovered and the steam from the left-hand end of the cylinder may not only exhaust through the ports P in the cylinder, which are controlled by the piston, but also

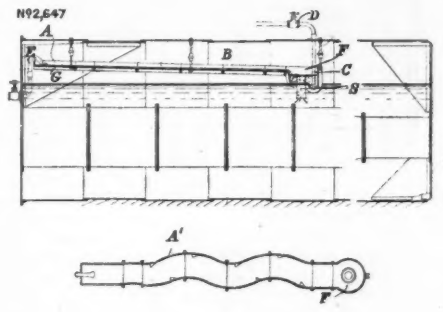


through the auxiliary exhaust passage G to the casing E and thence to the auxiliary exhaust outlet H. This state of affairs continues until the compression pressure on the left-hand side of the piston K is greater than the steam pressure on the right-hand side of the piston. Since the compression pressure is not allowed to rise very quickly owing to the exhaust passage O being open, this auxiliary pressure will continue for a very considerable part of the stroke from right to left and thereby only a very low compression will be attained, such as is sufficient to meet the requirements during starting or at low loads. In the form illustrated, where the exhaust passage O does not open into the extreme end of the cylinder, but only in the region of the inlet end, the piston K in its stroke, as can be seen at the right-hand side of the figure, covers the auxiliary exhaust passage which is thereby automatically cut out, so that sufficient compression is secured to ensure proper cushioning, and also to ensure that the valve F is operated by inlet steam before the passage O is uncovered at the inlet end by the piston. In this way it is impossible that live steam can escape through the auxiliary exhaust passage O.—*November 24th*, 1909.

STEAM GENERATORS.

2647. February 4th, 1909.—IMPROVEMENTS IN AND RELATING TO INTERNAL FEED-WATER HEATERS FOR STEAM BOILERS, Frederick Cockayne, of Commercial Bank Chambers, Albert-street, Derby; John Cockayne, of 3, Orford-street, Longport; and Charles Edward Medcalf, of Clarence Chambers, 39, Corporation-street, Birmingham.

A number of horizontal cast iron trays A having undulated sides A' are disposed in the steam space B of the boiler G, the trays being made of various widths and depths as circumstances may require to suit different forms and sizes of boilers. The trays A may be bolted together by flanged ends, so as to form a long tortuous channel which terminates in a large bowl-shaped vessel or pan F, in which a pipe C and valve D are arranged for the purpose of blowing out any collected deposit of lime, salts, mud, and the like that may accumulate therein. An inlet pipe E is arranged provided with the usual fittings. The feed-water, which may be previously heated by exhaust steam, waste heat, or

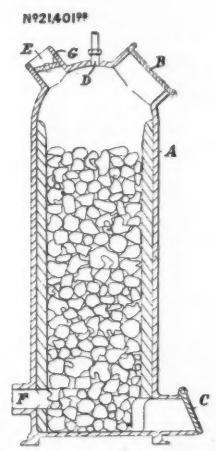


flue gases, or other heating arrangement, is delivered on to the inlet end G of the internal heater A, over which it travels slowly, making frequent changes of direction through the curved path of the trays, which causes the water to be churned from the sides to the centre and thus breaks it up so that every portion is brought into direct contact with the steam, so that by the time it reaches the settling bowl B and overflows through tube S into the body of the boiler the water has been heated up to the full temperature of the steam. To assist in the churning action, angle pieces may be disposed on the inner side of the heater to thereby direct the water towards the centre.—*November 24th*, 1909.

INTERNAL COMBUSTION ENGINES.

21,401. April 13th, 1909.—AN IMPROVED VAPORISER FOR INTERNAL COMBUSTION ENGINES, Georges Willes Stallard, of 88, Bramhall Moor-lane, Hazel-grove, Stockport, formerly of Horton-crescent, Rugby.

This invention has relation to that type of vaporiser in which heavy mineral oil is passed through a heated chamber containing incandescent material in order to decompose the more complex hydrocarbons composing the oil passing therethrough, the present invention comprising an improved combination of elements forming a more simple and effective apparatus than hitherto. A single chambered hot vessel A is used, which may be heated by an internal coke fire raised to incandescence by natural or forced draught, at starting, and by the engine suction when running. The chamber is provided with a charging door B at the top and ash removing door C at the lower part. The oil is delivered through the inlet nozzle D on to the heated coke, thereby forming a fixed gas, which mingles with the carbon monoxide gas produced by the induced air current passing in at the pipe E and downwardly through the fire to the induction pipe F, in which pipe a

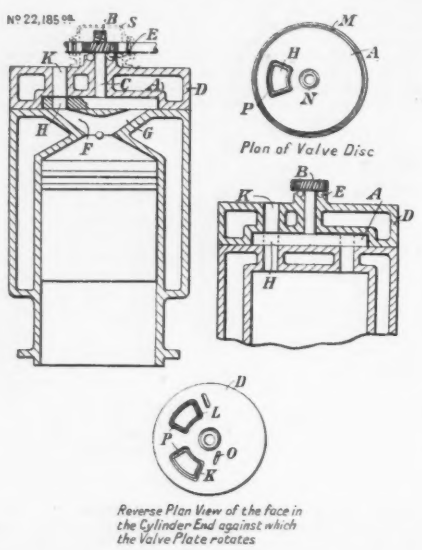


mixing valve, not shown, is situated in order to admit the air required to form an explosive mixture, a throttle valve G being arranged at the upper part of the hot vessel A to regulate the air passing thereto; the quantity of air admitted to the hot chamber being small, the amount of coke consumed is correspondingly small, only sufficient air being supplied to retain the fuel and chamber A at the correct temperature to gasify or vaporise the oil, thus enabling the vaporiser to be more economically worked than the usual type of suction gas producer and to be of small dimensions for a given horse-power. A suitable scrubber may be disposed between the vaporiser and mixing valve to remove tarry matter. The air and oil supply may, if desired, be hand or governor controlled and the chamber lined with refractory material. The oil is preferably supplied by means of a pump of any suitable type.—*November 24th*, 1909.

22,185. April 25th, 1909.—IMPROVEMENTS IN AND RELATING TO THE VALVES OF INTERNAL COMBUSTION ENGINES, William Cochrane, 26, Charges-street, Mayfair, London, W.

This invention relates to rotary disc valves of internal combustion engines. The valve consists of a simple disc A adapted to be rotated by skew gearing B mounted on a shaft C attached to the centre of the disc A; the shaft C extends through the water-jacketed detachable cylinder end D, and is fitted with ball or roller bearings E adapted to take the thrust on the valve spindle bearing from the skew gearing. The end of the cylinder is coned, and has two ports F G, inlet and outlet respectively, adapted to register alternately with a port H in the disc valve A. The coned formation of the cylinder end permits a water jacket being arranged under the disc valve, and the detachable cylinder cover being also water jacketed or air cooled, the disc valve will thus be properly cooled on both sides. The cylinder cover also has an inlet port K and an outlet port L; the ports K, L, H may be of any preferred shape, but they are preferably of the shape shown. For lubricating purposes and to prevent grinding and leakage of the charge during compression, the disc valve has inner and outer

grooves M N, to which oil is supplied from the opening *o* in the cylinder cover. The ports are also grooved as shown at P. The

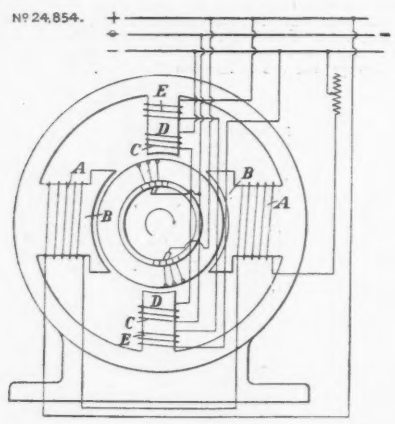


shaft C is driven by any usual 2 to 1 gearing through skew gear, preferably covered in by a light casing S filled with lubricant.—*November 24th*, 1909.

DYNAMOS AND MOTORS.

24,854. November 18th, 1908.—Improvements in and relating to Dynamo Electric Machines, The British Thomson-Houston Company, Limited, of 83, Cannon-street, London, E.C., and Frank Percy Whitaker, of 237, Clifton-road, Rugby.

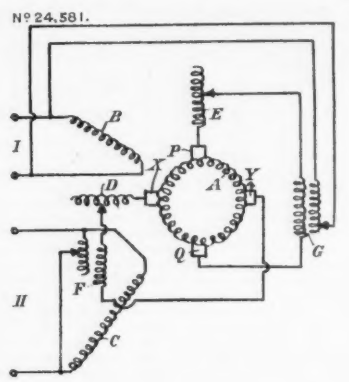
The object of this invention is to provide an improved split-pole rotary converter adapted to run at unity power factor or approximately unity power factor at all loads from no-load to maximum working load at constant potential or over-compounded without employing reactances or boosters. A dynamo-electric machine is employed, having a shunt winding A on the main poles B, and a series winding C on the auxiliary poles D, for the purposes of producing the commutating field, and for changing the ratio between the alternating-current and direct-current volts. The main pole and the auxiliary poles are so arranged that at no-load the required ratio is obtained between the alternating-current and the direct-current volts, and at full load its ratio is changed by means of



the auxiliary pole, so as to compensate for the drop in the line, transformers, and rotary converters, and, when necessary, the over-compounding of the rotary. In order to increase the range of ratio, a differential winding E may be wound on the auxiliary poles D, so that at no-load the shunt winding produces a flux in the reverse direction to that produced by the series winding C as the load increases. In the ordinary type of split-pole rotary converter it is usual when converting from alternating to direct-current to give the brushes a slight forward lead, and commutate in the fringe of the main pole, which is approximately of constant strength. Since the flux density under the auxiliary pole increases approximately proportionately to the load on the machine, the machine in this case is run towards the auxiliary pole in the direction of the arrow, and thus use the latter as a commutating pole, in addition to varying the ratio between the input and output volts. The essential feature consists in varying the voltage ratio, and the provision of a commutating field of a density which increases with the load by arranging that at full load the greater portion of the flux from the auxiliary poles must enter the armature on that side of the axis of commutation nearest the main pole of similar polarity.—*November 24th*, 1909.

24,581. November 16th, 1909.—Improved Means for Regulating Polyphase Electric Commutator Machines, *Allmänna Svenska Elektriska Aktiebolaget, of Westeras, Sweden, and Jens Larsen La Cour, also of Westeras, Sweden.*

This invention relates to improved means for regulating polyphase commutator machines of the induction type in contradistinction to machines of the conduction type. A is the armature winding, and B and C the main windings. These windings are in the usual manner mounted on the stator with an angular difference of 90 electrical degrees, and are disposed in slots at the inner surface of the stator core. D and E are adjustable auxiliary windings which correspond to the main winding B and C respectively, and also are disposed in slots arranged at the inner surface of the stator core. The armature winding A is, by means of brushes X and Y, connected in series to the adjustable auxiliary winding D, while the corresponding main winding B is directly connected to the first phase I of the network. In analogous manner, the armature winding A is in direction at right angles to the brushes X Y, connected in series by brushes P Q to the adjustable auxiliary winding E, while the corresponding main winding C is directly connected to the second phase II of the network. In the armature circuits are further connected the secondary windings F and G respectively of transformers, the primaries of which are connected to the phases II and I respectively of the network. By means of the winding F, a magnetising current, the phase of which agrees to that of phase II of the network, is induced in the armature winding in the direction X–Y, and, in analogous manner, a magnetising current, the phase of which agrees to that of phase I of the network, is induced in the armature winding, by means of the winding G, for magnetising the arma-

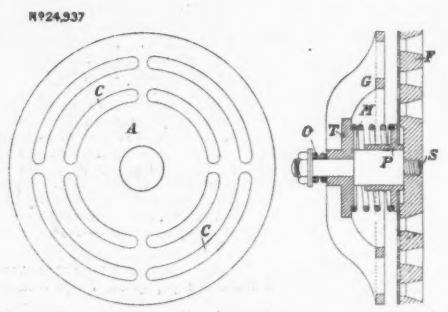


ture core in the direction P–Q. When the motor runs the currents induced by means of the windings F and G causes the power factor to be high, so that the motor takes up only small wattless currents from the network. The speed is varied by altering the voltage ratio of the transformers. There are five other illustrations.—*November 24th*, 1909.

PUMPING AND BLOWING MACHINERY.

24,937. February 17th, 1909.—Improvements in or relating to Valves for Blowing Engines, Compressors, and the like, John Scarisbrick Walker, Thomas Ascroft Walker, and Edwin Robert Walker, all of Pagefield Ironworks, Wigan, Lancaster.

A is the valve plate formed with arc-shaped slots as indicated at C; F is the seating which is formed with a series of grid-like openings which are covered by the imperforate parts of the valve plate as indicated; G is the guard which serves to limit the opening movement of the valve. The guard is supported on the central stud having a threaded end piece S which is screwed into the centre of the seating F. The centre part T of the guard G rests against the shoulder of the enlarged middle portion of the stud and is held up from the rear by a compression spring O and

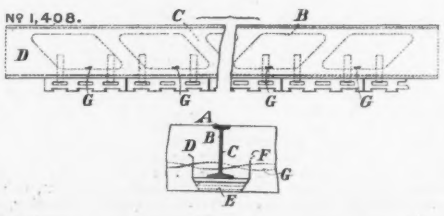


a nut, the position of which can be adjusted in order to vary the spring pressure. The valve plate A is open at the centre and a sliding hub P is provided so as to work over the stud and to be guided thereby. The hub has an enlarged disc-like portion against which a spiral spring M bears, the other end of the spring being supported against the centre part of the guard G. The inner end of the hub P projects through the central hole in the valve plate A and fits closely therein, so that the hub does not require to be actually fixed to the valve plate. It will be seen that with this construction the valve will be accurately guided during its movements, whilst the hub can be readily replaced if required.—*November 24th*, 1909.

MISCELLANEOUS.

1408. January 20th, 1909.—Improvements in Steel and Concrete Construction, Mark Fawcett, of 50, Queen Anne's-gate, Westminster.

The upper engraving shows an elevation and the lower a cross-section of the improved girder construction. For this purpose girders A of I-section are used, but with the bottom flanges larger than the top flanges, and with large rhomboidal-shaped perforations or openings B in the webs, the metal C between such openings being inclined right and left of the centre nearly up to each end, which is kept solid to resist the shearing stresses. A lattice girder is thus formed with the compression bars removed, these not being necesary to take the compression when good concrete is employed, and for the same reason less metal is required to take



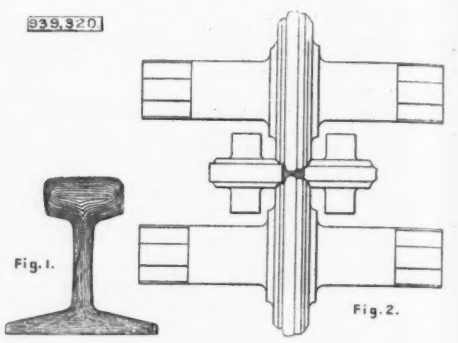
the longitudinal compression, as this is obtained from the concrete itself. These girders are placed at varying distances apart to suit the spans and loads, and, centering having been placed below or suspended from above, the concrete D is filled in, and allowed to extend 1½in. to 2in. below the girders and come level or above the top. This concrete D, passing through the large rhomboidal-shaped perforations or openings B in the web, becomes, when set, one monolithic mass, in which the girders are imbedded. To allow for the expansion of the girder, tiles E can be used under the bottom flanges of the girders, which tiles can be utilised as a packing for fixing the centering. The use of such tiles E also prevents discoloration of the ceiling such as occurs when concrete is in close contact with the bottom flange of the girders. These tiles E can be held in position by forming them with bevelled edges as shown, around which the concrete sets. In addition, pieces of hoop iron F can be employed, passing through the slots e^1 of the tile, the ends of which are bent outwards, and extend into the concrete itself, on which they become imbedded. The bottom flanges of the girders resist the tensional stresses, and the concrete, assisted by the small top flanges of the girders, resists the compressional stresses, and any tendency to expand in the direction of the length of the girders is resisted by the web metal C holding against the concrete in the rhomboidal-shaped perforations B. Expansion in the opposite direction—that is, at right angles to the girders—is resisted by placing twisted metal strips or bars G in the rhomboidal-shaped perforations, which become imbedded in the concrete. Such bars also serve to reinforce the concrete transversely between girder and girder.—*November 24th*, 1909.

SELECTED AMERICAN PATENTS

(From the United States Patent-office Official Gazette.)

939,320. Method of Manufacturing Rails, *N. Readtman, Knoxville, Pa., assignor to Jones and Laughlin Steel Company, Pittsburg, Pa., a Corporation of Pennsylvania.—Filed September 29th*, 1908.

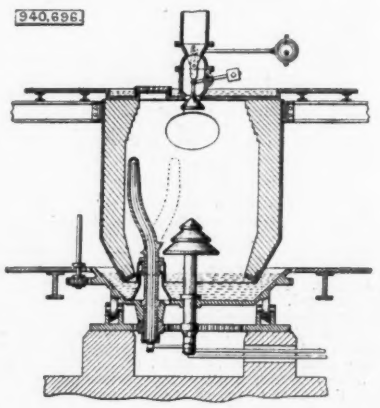
This patent is one of two for a method of improving the quality of rail tables. The first is for a rail having the strata



formed in the head and flange during reduction, disposed in planes substantially at right angles to the direction in which load is applied to the rail, as shown in Fig. 1. The second is for the rolling mill, Fig. 2, which submits the rail to horizontal pressure, as shown. There is one claim to the first patent, three to the second.

940,696. Gas Producer, *R. B. Kernohan, Pittsburg, Pa.—Filed April 13th*, 1909.

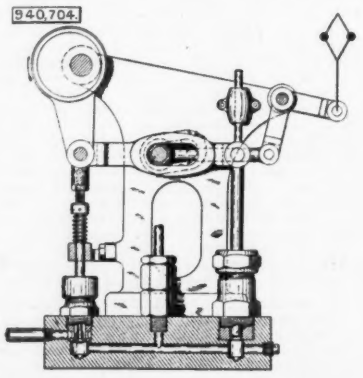
The main feature of this invention is the use of a rotative stirrer



or poker which can be caused to rotate inside the charge. There are seven claims.

940,704. Pump, *N. McCarty, Indianapolis, Ind., assignor to Atlas Engine Works, Indianapolis, Ind., a Corporation of Indiana.—Filed June 14th*, 1909.

The drawing is self explanatory. The patent is for an arrange-



ment by which the stroke of the pump is varied by a governor which shifts the fulcrum, as shown. There are six claims.

A New Method of Preserving Wood.—With reference to the paragraph under the above heading in our last issue, we desire to correct an error in line 14. Among the advantages claimed for cresol-calcium is its non-inflammability, and not, of course, its inflammability, as was by error misprinted in the paragraph above mentioned.

THE ENGLISH UNIVERSITIES AND ENGINEERS.

(By a London Professor.)

SIR WILLIAM WHITE, from the presidential chair of the Institute of Metals, recently rebuked those people who constantly belittle this country and its achievements in Applied Science. His words were chiefly directed to the writers and owners of the halfpenny papers. During the last decade we have heard a great deal about the wonderful equipment of the American technical colleges. It may surprise some readers to learn what is being done in England. We have not been altogether listless or asleep. Many of us would have gladly welcomed a heartier response to certain appeals for more money for the engineering departments of our Universities. We may hope that many public-spirited men in this country will take as much interest in higher technical education as is done elsewhere. But it is only fair to add that during the last decade large sums have been obtained from generous donors—many of them men who are well known to readers of this journal as "captains of industry."

For the purposes of our survey of what has been done for University education for engineers during the last four or five years in this country, we will consider first London and then the provinces. It may be well, however, to state that ten years ago the only engineering course leading to a degree in this country was that of the Victoria University. Now the youth in the remotest village of Yorkshire, Cumberland, or Cornwall, may burn the midnight oil at home in preparation for graduation as a B.Sc. (Engineering) in the London University. Birmingham, Durham, Liverpool, Manchester, Leeds, Sheffield, and Bristol now possesses Universities empowered to give the capable engineering student a degree in his own branch of applied science. Engineering is duly recognised as a subject worthy to be accepted in the curricula of those ancient seats of learning at Oxford and Cambridge. These facts of themselves must surely satisfy the croakers that the status of the engineering profession has improved during the last few years. Let it be understood at once that these degrees are by no means intended to be professional certificates; they are not to be interpreted as meaning that the graduate is a capable engineer. It is fully recognised by the University authorities that experience only can do that. But the degree does prove that the student has attained a certain knowledge, and it usually means that he has been through a definite College course. He has given serious study to the fundamental principles of engineering science. The degree also shows that courses of instruction have been given to the student in the laboratory, and some general designing and college drawing-office practice accomplished. If the degree needed defending, that could be done in a sentence. It offers the student a reward for industry, it stimulates him to do his best, and it provides a method of ensuring discipline.

Dangers of degrees.—It may be suggested by thoughtful onlookers that there is a danger in multiplying the facilities for obtaining University degrees in engineering. "After all," they may say, "there must be competition among the various Universities, and each one will endeavour to show a long roll of graduates. There will be a temptation to lower the standard of the degree." Or again, it may be reasonably urged, that it is impossible for the busy man to differentiate between an engineering degree obtained in London, Birmingham or Bristol. It is also conceivable that a man possessing a degree may be a mere "bookish" person, who has not the remotest instinct of proportion and the ways of human nature, so essential to an engineer. All these things may be true, but is only fair to examine the replies which can be given. With regard to the vexed question of the standard of the degrees, it must be remembered that each degree is rewarded on the recommendation of examiners, some of whom are attached to the Institution at which the student has attended, while others are "external" and are attached to other Universities. It is reasonable to suppose that, as these "external" examiners are appointed for not more than three years, the standard at all of the Universities is about the same. If any place lowered the standard the result would be to its own detriment, and that fact is fully recognised. Although it may be difficult for the busy man to distinguish between the various degrees, he can feel satisfied that they all mean about the same general standard, except, possibly, Oxford and Cambridge. These Universities must be considered apart from the more modern places. As for the "bookish" graduate, that is the weakness of any examination system. It is not pretended by the advocates of University education for engineers that the existing system is a perfect one. It does seem to be the best possible under the complex circumstances. It makes it compulsory for a man to have a certain knowledge of theory; he must have the practice as well. That is not a problem to be solved by the University, although every encouragement is to be given to perfecting arrangements, so that graduates may obtain experience immediately after passing their examinations. In some places the "sandwich system" works well. The ideal arrangement is probably the old Admiralty system whereby a student obtained, on an average, about three hours' theory and six hours' practice a day. Such a system is only possible with the resources of a Government department.

Colleges and polytechnics.—The London University is similar in some respects to those in the provinces, but quite different in one feature. The University of the metropolis offers two ways of obtaining an engineering degree. One system was designed for the youths in the London colleges, the other for those who cannot attend colleges. The two sets of students are known as "internal" and "external." To obtain an "internal" degree a student must matriculate, spend at least three years after matriculation in a London college under the supervision of "recognised teachers," and take a course of study approved by the University. A student may attend evening classes and rank as "internal" under the above conditions. He must pass an intermediate examination in mathematics, physics or chemistry, and mechanical drawing, after which he may proceed to study for the final. In that examination he has a fairly wide choice of subjects. He must select three out of the following four, viz.:—(1) Strength of Materials; (2) Theory of Structures; (3) Theory of Machines; and (4) Electrical Technology. He must satisfy the examiners in the three subjects selected. This is called Group A. A further set of subjects—Group B—contains (5) Hydraulics; (6) Surveying; (7) Theory of Heat Engines; (8) Design of Electrical Machinery and Apparatus; (9) Generation, Transmission, and Distribution of Electrical Energy; (10) Mathematics; (11) Advanced Theory of Machines and Structures.* In order to obtain a "pass" degree it is necessary to select and satisfy the examiners in two out of these last seven subjects. To obtain an honours degree three of the Group B subjects must be taken successfully in the examination. If a man selects three subjects in Group B, and fails in one, he obtains a pass degree. These regulations hold both for external and internal students, although separate papers are set for the two examinations. The "internal" student obtains certain marks for his course work, *i.e.*, he submits the designs and notes of laboratory experiments which he has done while studying for the degree. The "external" student does certain designs during the course of the examination (such as a girder, a boiler, a water turbine, &c.), according to the subjects taken. Questions concerning laboratory work are set in the examination; it is a great pity that the "external" student does not necessarily have actual experience in laboratory work. He may study in Timbuctoo, but he is examined in London.

Internal students may attend certain of the chief centres of engineering instruction in the metropolis. University College, King's College, the Imperial College of Science and Technology, and the East London College, are officially known as "Schools of the University." Students who attend these schools are qualified to sit for University examinations, provided only that they have been credited with the requisite number of hours attendance. There are also "Institutions having recognised teachers." Those which provide for engineering are Battersea Polytechnic, the Northampton Polytechnic Institute, the South-Western Polytechnic Institute, the Technical College, Finsbury, the Northern Polytechnic Institute, and the Woolwich Polytechnic. In these latter institutions, students must attend certain courses under teachers "recognised by the University" as sufficiently qualified for the purpose.

In the matter of equipment, the schools of the University are better off than the other institutions, although some of the latter places have excellent apparatus. It may be said at once that there is no single institution in the metropolis which has such equipment as the University of Birmingham.

It is probable that the Imperial College will soon be able to provide the students with apparatus and equipment worthy of the metropolis. But at present London lags behind. University and King's Colleges have great traditions. The former has an especially strong school of civil engineering, and the electrical department, under the distinguished Professor Fleming, has made a world-wide reputation for research work. In the mechanical engineering department, Professor Cormack is engaged upon research work in connection with worm gearing. Sir Alexander Kennedy created traditions whilst he held the chair of engineering at University College. The engineering laboratory was the first of its kind in this country.

Strength of materials equipment.—Throughout the country the University Colleges have laboratories equipped somewhat on the following lines. For strength of materials a 50 or 100 tons machine is used for tension, compression, and bending tests. In most cases there is apparatus for shear or rivet tests. Usually a smaller machine for testing wires is installed. Impact testing machines are fairly general. Experiments on the deflection of beams (to find E) and the torsion of wires (to find C) are invariably arranged. A separate torsion machine is also usually provided. One or two forms of extensometer are used—the telescopic form of instrument seems to be most popular. Useful research work is being done in this subject of materials. In the metropolis several papers have recently been published. Professor Unwin's classical work for the Standards Committee can hardly be reckoned as University research work, although it was conducted at the Imperial College. Several papers on combined stress have been published from the East London College. The work has attracted considerable attention by reason of the ingenious sphingometer used for measuring strains, and the unexpected results showing excentric loading, obtained with it. An electrically controlled testing machine is used at the Northampton Institute, Clerkenwell, and the results of certain torsion tests have recently been published. The tests were conducted in a painstaking fashion, and further data will be awaited with interest.

Experiments with heat engines.—The equipment of the heat engine laboratories in most of the colleges in London and the provinces is after the following general arrangements. Two boilers—locomotive, water-tube or cylindrical—are usually installed. Superheaters are sometimes fitted. Professor Watkinson at Liverpool has one especially designed so that researches may be conducted. A compound steam engine, a single-cylinder steam engine, and a steam turbine are seen in most places. Steam calorimeters, various types of indicators, measuring tanks, &c., are provided, so that complete steam consumption tests may be made. Steam engine research work is not very evident just at present, although several efforts have been made to obtain decisive data. Professor Weighton's work at Newcastle on condensers is well known. Professor D. S. Capper, two or three years ago, presented to the Institution of Mechanical Engineers some results of his researches on valve leakage made at King's College. Other attempts have been made to solve certain steam engine problems. The difficulty is that each engine is a law unto itself. The internal combustion engine, on the other hand, is a popular subject for investigation. In most of the Colleges there are one or two gas engines, and frequently a suction gas producer. Petrol engines are also met with. At Cambridge Professor Hopkinson, at Birmingham Professor F. W. Burstall, at the Imperial College Professor Calendar, and at Finsbury Professor Coker, have all published researches upon matters relating to internal combustion engines. The usual type of laboratory work for the student is a series of tests, under various conditions, upon each engine installed. The engines are either coupled to dynamos or to brakes. The tests are usually thermal and mechanical efficiency tests. It is good practice for the student. Practically every institution (with the possible exception of Birmingham) in this country, requires to develop its heat engine equipment. It is perhaps hardly fair to enumerate individual institutions, but for heat engine equipment the visitor obtains the impression that the University of Birmingham, with its power station, is a long way ahead of the other Universities. The Universities of Liverpool and Sheffield seem to be the next in order. London again lags behind, although all of the colleges have very fair equipment. If the earnest student wishes to obtain good heat engine testing experience he can find the plant necessary in all the London Colleges; there is, however, little opportunity for research work.

Experimental hydraulics is a subject that is comparatively new, but it has come to stay. Here, again, Birmingham is right ahead of any other University. The two concrete channels, 200ft. long, and the 6in. pipe lines, &c., are magnificent. Finsbury College has a very fine hydraulic laboratory. The Leeds University has recently built one, and the Liverpool University will shortly do great things. In this connection it is worth noting that the latter University has recently appointed a Professor of Naval Architecture, and there is a great deal in common between naval architecture and hydraulics. At Sheffield University there is some useful plant, but the space is small. London, again, lags behind—Finsbury is the one place worth mentioning in connection with this subject. Experimental work in hydraulics is essential if the elements of the turbine and pump design are to be grasped. The various colleges are severely handicapped, and in almost every case money is required for hydraulic apparatus. The Imperial College recently obtained £4000 for a new laboratory for this subject. The other London Colleges want more funds for similar equipment.

The elements of civil engineering are taught, but the attempt to give advanced courses to any students except graduates is not to be encouraged. Structural design is dealt with chiefly in the drawing-office. Surveying field work is carried out. In some cases a summer camp for surveying work is arranged, and is usually a success.

Electrical engineers are well provided for at the colleges, and more money seems to have been spent on equipment for this branch of engineering during the last ten years than any other. Birmingham, Leeds, the Imperial College, Liverpool, King's, and University Colleges are well provided with experimental apparatus. The usual equipment is a large laboratory for electrical machines such as A.C. and D.C. motors, rotaries, and transformers. A photometric room is provided for lamp tests. A junior laboratory is equipped with galvanometric, hysteresis, and other bench tests. Invariably a departmental drawing-office is used for design purposes. A great deal of so-called research work has been turned out in this branch of engineering during the last three or four years. Some of it has been really physical research, whilst some has been merely routine testing. The colleges which seem to have turned out good original work in London are University, King's, and East London, and in the provinces a brilliant Birmingham graduate working at Liverpool has made a reputation. Many of the Universities have done electrochemical researches, but that is not suitable for discussion here. It may be well, however, to point out that there seems to be far more opportunity for original work in electrical work than any other branch of engineering.

Metallurgical and mining work is done at the Imperial and King's College, London, and the Universities of Sheffield, Birmingham, Leeds, and Durham. At Sheffield and Birmingham the equipment is on a very large scale, and could hardly be improved. It is doubtful whether other University Colleges should attempt to provide instruction in these subjects. Possibly it would be wise to have a lecturer in metallurgy and a small laboratory for microscopic work in the mechanical engineering department.

So much for the general outlines of the equipment. It is appreciated that statistics are dangerous, but it may be of interest to mention that in London there are, at the schools of the University, about 500 day students in engineering, most of whom have passed the matriculation. There are probably about 150 other engineering students of the same type in the Polytechnics, day and evening. In addition, these institutions have large numbers of Board of Education students, but they represent work done in the provinces by the technical schools which is not being considered in this article. The Universities of Birmingham, Liverpool, Leeds, Sheffield, Manchester, Durham, and Bristol, have together about 500 students. There are, therefore, in England at present from 1000 to 1200 students seriously studying and taking a course which leads to a University degree. It is a surprisingly high figure, but at Cornell, there are 1700 engineering students. It is curious that the proportion of engineering students at the University, to the population, is very much greater in the United States than in this country. The American youth seems to be determined to obtain a University education. Their fees are lower than in this country.

We have it on reliable authority that the engineering equipment at the University of Birmingham is second to none in the world. It is certainly an example to the

* It is worth observing that a student is not obliged to take an electrical subject under either heading. Rather anomalous in view of the present position of electricity. Some test of his knowledge in that subject should be required.—Ed. THE ENGINEER.

London Colleges. The metropolis presents a complex problem. There is at present a Royal Commission taking evidence on University Education in London, and the subject of applied science work will be considered carefully. For the medical profession there are various training places in London, and it is reasonable to suppose that several colleges are needed in which engineers can be trained. These places are in existence, but they want better equipment. London should be able to offer to the British subject the best education for any profession in the world. It leads in law and arts. In London there are all of the most prominent experts in engineering. London is enormously wealthy. Several patriotic men have given large sums for the development of applied science at Birmingham, Manchester and Liverpool. £100,000 is badly needed for applied science equipment by each of the schools of the London University. The City Companies and Guilds have assisted to their everlasting credit. They have done a great deal to keep burning the flame of research. More might be done by the private citizens.

This article began with the mention of the name of Sir William White. It is fitting to close it by paying a tribute to his unselfish and tremendous efforts on behalf of University education for engineers. Every engineer may not fully know of it or appreciate it at present; but a future generation will understand more fully, because the benefit will then be reaped.

LOCOMOTIVE PROPORTIONS AND POWER.

By G. James Wells, Wh. Sc., Assoc. M. Inst. C.E., M.I. Mech. E

No. II.*

Another instructive set of figures is that shown in Table II. (*ante*), relating to the coupled engines of the Great Northern Company, and an examination of it gives identically the same lessons as those disclosed by the reached his present position *viâ* one type (990) only, a magnificent record.

Some interesting examples are given in Table III. (*ante*), which are taken from the practice of the Midland Company's Locomotive Department. Mr. Johnston's practice was always to use comparatively small boilers for his engines, and this is borne out by the figures in the table. The first engine, No. 800, is the well-known Kirtley engine, which has done much remarkable work, and the values of the factors are in accordance with this result. Mr. Johnston in his first engine reduced both factors, and in the next type, 1562, these values were still further reduced. In his next engine, the Princess Beatrice, the boiler factor is increased, but is still smaller than that of Mr. Kirtley's No. 800, but the adhesion weight is again less. The engine 1668 belongs to a small class of five in which the cylinder capacity was largely increased, but the then standard boiler employed, so that this engine marked a very great reduction of the boiler factor, so much so that they were subsequently rebuilt to the Princess Beatrice dimensions, the cylinder capacity being reduced and the heating surface being increased. The cylinder capacity of the original 1668 reappears next in the 150 class, but this time the boiler factor is retained at the apparently irreducible minimum for the Midland Company's system of 210, a value which agrees with that disclosed in the other tables. In the next type of engine, 2607, Mr. Johnston used a value for the grate area factor greater than that of 800 for the first time, and these engines were so successful that the same type of boiler has since been fitted to all the older engines that were worth the expense of rebuilding.

In the succeeding 863 class an increased steam pressure was given, the boiler having the same capacity, but the adhesion factor reaches its lowest value. In Mr. Deeley's latest type 990, the boiler is on a greatly increased scale, and the adhesion factor is increased, but is still apparently very low.

An examination of Tables IV. and V. shows that the development of the single-wheeled engines has proceeded along the same lines as the coupled engines, both as regards adhesion and grate area factors. Table IV. relates to Great Western engines, whilst Table V. refers to Great Northern practice. It is curious to note that the designers of single-wheeled engines have been uniformly of the opinion that they required a more liberal allowance of boiler power than coupled engines, as the grate area factor for contemporary engines is always smaller. It will be remembered that Mr. Stirling said that his single-wheelers always beat his coupled engines when set to work the same class of traffic; but he did not point out that the latter had relatively much less boiler power. Taking as a basis engine No. 771, then the heating surface of No. 869 would have been 1148 square feet and the grate area 19.5 square feet. Mr. Ivatt, in his 400 class, which was a rebuild of 869 so far as regards the engine power, realised these proportions and the excellence of these engines illustrates the value of these factors in proportioning a new type. Table VI. illustrates clearly how if Mr. Stirling had used these factors, and recognising the good work done by his big singles, had taken them as the basis, might have anticipated Mr. Ivatt's engines which are to-day doing work that the big singles could not possibly do.

Similarly, Mr. Dean's "Gooch" was given a smaller boiler than his contemporary singles, and Table VII. illustrates how, if the "Gooch" had been treated as liberally as the Achilles single, the "Atlantics" of Mr. Churchward would have resulted. It seems clear, therefore, that the practice which obtained upon both the Great Western and Great Northern systems of giving the singles the most exacting work to do and restricting the less arduous trains to the coupled engines had resulted in allowing the singles the larger boilers, apparently without disclosing the handicap this was to the coupled engine when put to do the same work as the single-wheeled type.

Four cylinder engines are being multiplied, and in Table VIII. some examples are given. The first example given is the engine to which Mr. Manson fitted four cylinders, but retained the then standard boiler, thus increasing the cylinder capacity without altering the boiler, so that the grate area factor was virtually reduced. It still remains the only example of its class on the Glasgow and South-Western, so that it may be presumed that the results obtained were not good enough to warrant its repetition; and, judged from the knowledge obtained from the discussion of the preceding tables, this might be anticipated. In the then standard engine the grate area factor is 217.5—and it is seen from the practice exhibited in Tables I., II., and III. that 210 appears to be the limiting value—so that increasing the cylinder capacity 7 per cent., and thus giving the grate area factor a value of 232, was making worse the poverty-stricken condition of the standard engine; it is therefore necessary to see how the engine could run with such a small boiler.

It has been stated that the lap on the valves was increased to prevent the engine running itself out of *breath*. The next example is Mr. Webb's Iron Duke, in which the grate area factor was 227, and therefore foredoomed to failure. The following is Mr. Ivatt's 271, which, with the same cylinder capacity as Mr. Manson's No. 11, has been provided with a grate no less than one-third greater area, a somewhat startling comparison. Mr. Drummond has been building four-cylinder engines, and his successive stages are interesting. The last example is fitted with a superheater, hence the factor in this case cannot be directly compared with the other examples, except Mr. Churchward's Great Bear. From a comparison of the Drummond 335 and the Great Bear it would appear that the Great Western people do not attach so much value to the superheater as Mr. Drummond.

The data employed in the calculations of the foregoing tables have been obtained from the pages of The

Table IV.

Type.	Cylinders, diameter × stroke.	Driving wheels, diameter.	Cylinder volume per mile.	Total heating surface.	Grate area.	Cylinder volume divided by: Heating surface.	Cylinder volume divided by: Grate area.	Boiler pressure, lb. per sq. in.	Total tractive force.	Calculated weight on driving wheels.	Actual weight on driving wheels	Act. weight / Cal. weight	
	in.	ft. in	cu. ft	q. ft	sq. ft.				lb.	tons.	tons.		
2-2-2	16 × 24	7 1	2651	1241	14·62	2·14	228	120	6,206	14·45	—	—	Gooch, No. 157
2-2-2	17 × 24	7 1	2990	1203	16·77	2·49	178	140	8,567	19·04	14·00	0·735	Armstrong, No. 378
2-2-2	18 × 24	7 1	3355	1214	19·30	2·76	174	140	9,607	21·35	15·50	0·726	Dean No. 158
2-2-2	18 × 24	7 1	3355	1328	21·0	2·53	167	150	10,390	22·88	16·00	0·699	,, 158
2-2-2	20 × 24	7 8½	3806	1445	20·8	2·64	183	160	13,550	30·11	19·00	0·631	,, 3021
4-2-2	19 × 24	7 8½	3436	1561	20·8	2·21	165	160	12,240	27·19	18·00	0·662	,, 3051
4-2-2	18 × 24	8 0	2970	1769	21·7	1·68	137	115	6,986	15·52	12·3	0·792	Gooch-Dean broad gauge
4-2-2	18 × 24	8 0	2970	2085	2·.7	1·42	137	140	8,505	18·90	16·0	0·846	,, latest ,,

Table V.

Type.	Cylinders, diameter × stroke.	Driving wheels, diameter.	Cylinder volume per mile.	Total heating surface.	Grate area.	Cylinder volume divided by: Heating surface.	Cylinder volume divided by: Grate area.	Boiler pressure, lb. per sq. in.	Total tractive force.	Calculated weight on driving wheels.	Actual weight on driving wheels.	Act. weight / Cal. weight	
	in.	ft. in.	cu. ft.	q. ft.	sq. ft.				lb.	tons.	tons.		
4-2-2	18 × 28	8 1½	3412	1045	17·75	3·26	192	140	9,770	21·71	15·00	0·691	"Stirling" No. 1
4-2-2	18 × 28	8 1½	3412	1045	17·75	3·26	192	160	11,160	24·82	17·00	0·685	,, 771
2-2-2	18 × 26	7 7½	3376	1045	17·75	3·23	190	160	11,050	24·56	17·40	0·708	,, 876
4-2-2	19½ × 28	8 1½	4004	1032	20·0	3·88	200	175	14,330	31·84	19·20	0·603	,, 1003
4-2-2	19½ × 28	8 1½	4004	1032	20·0	3·88	200	175	14,330	31·84	18·00	0·5653	,, 1003
4-2-2	18 × 28	8 1½	3412	1210	23	2·82	148	175	12,220	27·14	18·00	0·663	"1 att" 7.6
4-2-2	18 × 26	7 7½	3376	1269	23	2·66	147	175	11,740	26·08	17·75	0·680	,, 236
4-2-2	19 × 26	7 7½	3762	1269	23	2·96	164	175	13,400	29·77	18·00	0·605	,, 267

Table VI.

Type.	Cylinders.	Diameter of driving wheels.	Cylinder capacity per mile.	Total heating surface.	Grate area.	Cylinder capacity ÷ heating surface.	Cylinder capacity ÷ grate area.	Engine No.	
	in.	ft. in.	cub. ft.	sq. ft.	sq. ft.				
4-2-2 ...	18 × 28	8 1½	3412	1045	17·75	3·26	192	776	Mr. Stirling's original design
2-4-0 ...	17½ × 26	6 6	3744	929	16·25	4·03	230	869	,, ,, ,,
2-4-0 ...	17½ × 26	6 6	3744	1148	19·5	3·26	192	869	Calculated on the same basis as Mr. Stirling's 776
4-4-0 ..	17½ × 26	6 7½	3672	1124	17·8	3·26	206	400	Mr. Ivatt's original design
2-4-0 ...	17½ × 26	6 7½	3672	1124	17·8	3·26	206	1061	,, rebuild of Stirling's
4-4-0 ...	17½ × 26	6 7½	3672	1250	20·8	2·94	176	1321	,, latest design

Great Western practice. There is, however, one interesting difference to be noted, viz., Mr. Ivatt has never apparently gone backwards in the values of his ratios, which indicates that he appreciated the controlling factors and recognised the limits. In his 4-4-0 types he maintained Mr. Stirling's engine, but improved the grate factor from 230 first to 206, and

* No. I. appeared December 17th.

ENGINEER, *Engineering*, *Railway Engineer*, &c., and whilst it is impossible to vouch for exact accuracy, there is reason to believe that they may be taken as being substantially correct, and the figures obtained from them may be used for the purpose of comparison between the given designs, also the principal dimensions may be determined for a new type to give some predetermined duty.

The adhesion weight varies with the type of engine, and from an examination of the tables the value of the factor for single-wheeled engines should be about 0.70; for the four-coupled type it should be 1.00, and for the six-coupled type it should be about 1.20.

The value of the grate area factor is somewhat more difficult to assess, but remembering that it is a bad policy to force a boiler, probably its value should be about 150—that is, 1 square foot of grate area is required for each 150 cubic feet of piston displacement per mile, and the heating surface should be about 2.25.

Example (*i.*).—A single-wheeled express engine is required to give a tractive effort of 12,000 lb. with a boiler pressure of 180 lb.

Calculated weight on the wheel = 12,000 ÷ 450 = 26.6 tons, and the factor is 0.7, therefore the weight on the drivers must be = 26.6 × 0.7 = 18.7 tons, say 18 tons; with heavy rails perhaps 18.5 tons would be allowed.

Tractive force required per pound of steam

$$= 12{,}000 \div (0.75 \times 180) = 89 \text{ lb.}$$

The cylinder volume per mile is

$$= \left(\frac{19}{12}\right)^2 \times \frac{\pi}{4} \times \frac{26}{12} \times 2 \times 2 \times \frac{5280}{6.75 \times \pi} = 4250 \text{ cu. ft.}$$

Hence the heating surface must be 4250 ÷ 2.25 = 1889 sq. ft., and the grate area = 4250 ÷ 150 = 28.33 sq. ft.

	Cylinders.	Driving wheels.	Cylinder capacity.	Heating surface.	Grate area.	Steam pressure.	Tractive effort.	Calculated weight on drivers.	Actual load.	Act. load / Cal. load	Cyl. capacity / Grate area
	in.	ft. in.	cub. ft.	sq. ft.	sq. ft.		lb.	tons.	tons.		
Proposed engine	19 × 26	6 9	4250	1889	28·33	180	16,000	36·0	36	1·000	150
N.W. "Precursor"	19 × 26	6 9	4250	2010	22·40	175	15,220	33·8	38	1·124	190
G.W. "Cities"	18 × 26	6 8½	3838	1818	20·56	200	15,700	34·9	34	0·974	187
M.R. No. 2607	19¼ × 26	6 9	4315	1519	25·00	180	16,470	36·6	34	0·931	173

The comparison shows that the proposed engine has somewhat more generous boiler proportions than the examples selected, but the only outside dimension is the exact value of the grate area factor, however, will depend upon other conditions local to each system, such as the character of the fuel supplied, the loads to be hauled, speed to be maintained, and the gradients also would have to be allowed for, and this is the reason for some of the variations between the practice of our chief companies.

The case of compound locomotives has been deferred, as their number and relative importance, so far as British practice is concerned, is at present second to the simple

TABLE VIII.

Type.	Cylinders, diameter × stroke.	Driving wheels.	Cylinder volume per mile.	Total heating surface.	Grate area.	Cylinder volume divided by: Heating surface.	Cylinder volume divided by: Grate area.	Steam space.	Water-line area.	Cyl. volume divided by water-line area.	Water-line area divided by grate area.	Steam space divided by cylinder volume.	Boiler pressure, lb. per sq. in.	Total tractive force.	Calculated weight on driving wheels.	Actual weight on driving wheels.	Act. weight / Cal. weight	
	in.	ft. in.	cub. ft.	sq. ft.	sq. ft.			cub. ft.	sq. ft.					lb.	tons.	tons.		
4-4-0	14½ × 26 / 12½ × 24	6 9½	4172	1205	18	3·46	232	—	—	—	—	—	165	14,090	31·3	31·7	1·013	G. & S.W. No. 11
4-4-0	15 × 24	7 1	4660	1409	20·5	2·63	227	—	—	—	—	—	175	16,670	37·05	34·0	0·918	L. & N.W. "Iron Duke"
4-4-2	15 × 20	6 7½	4151	1303	24·5	3·181	169	—	—	—	—	—	175	14,860	33·01	32·0	0·969	G.N.R. No. 271
4-4-0	15 × 26	6 7	5431	1701	27·4	3·19	198	—	—	—	—	—	175	19,438	43·20	37·7	0·873	L. & S.W. No. 720
4-4-0	14 × 26	6 7	4730	1701	27·4	2·78	137	—	—	—	—	—	175	16,933	37·63	37·7	1·002	,, ,,
4-6-0	16 × 24	6 0	6251	2727	31·5	2·29	199	—	—	—	—	—	175	22,400	49·76	51·5	1·035	,, No. 330
4-4-2	14½ × 26	6 8½	4810	2143	27·1	2·24	177	97·7	102·25	43·31	3·772	0·02207	225	22,130	49·18	39·6	0·805	G.W.R. No. 40
4-6-0	14½ × 26	6 8½	4810	2143	27·1	2·24	177	97·7	102·25	43·31	3·772	0·02207	225	22,130	49·18	58·8	1·196	,, No. 4001
4-6-0	16½ × 26	6 0	7211	2727 s	31·5	2·64	229	—	—	—	—	—	175	25,800	57·33	52·5	0·916	L.S.W.R. No. 335
4-6-2	15 × 26	6 8½	5330	3400 s	41·8	1·57	127	—	—	—	—	—	225	24,540	54·54	60·0	1·100	G.W.R. "Great Bear"

s = these have superheaters.

Undoubtedly a large driving wheel is an advantage, so assume a diameter of 7ft. 7½in. when tires are new, and try a stroke of 26in., then

$$89 = (\text{cylinder diameter}^2 \times 26) \div 91.5;$$

or

$$\text{diameter of cylinder} = \sqrt{(89 \times 91.5) \div 26} = 17.7\text{in.}$$

Since the nearest even figure is 18, the cylinders would be 18in. × 26in.

The cylinder capacity per mile is

= (volume displaced by both pistons per revolution) × (revolutions per mile)

$$= \left(\frac{18^2 \times \pi}{144 \times 4} \times \frac{2 \times 26}{12} \times 2\right) \times \left(\frac{5280 \times 12}{91.5 \times \pi}\right) = 3376 \text{ cu. ft.;}$$

hence the total heating surface will be

$$= \frac{3376}{2.25} = 1500 \text{ sq. ft.} \quad . \quad . \quad . \quad . \quad . \quad (3)$$

And the grate area must be

$$= \frac{3376}{150} = 22.5 \text{ sq. ft.} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

grate area proposed, and this is on the right side, as recent practice tend towards larger areas.

Example (*iii.*).—Lastly, assume that 20,000 lb. tractive effort is required with 200 lb. steam pressure, 6ft. 9in. driving wheels, and a 26in. stroke. Then the calculated load on driving wheels = 20,000 ÷ 450 = 44·44 tons, so the engine must have six wheels coupled, and with a load of 17 tons per axle a total load of 51 tons will be a suitable adhesion load.

The tractive effort per pound of steam pressure

$$= \frac{20{,}000}{0.75 \times 200} = 133\tfrac{1}{3} \text{ lb.;}$$

hence the diameter of the cylinder will be

$$= \sqrt{\frac{133\tfrac{1}{3} \times 81}{26}} = 20.4\text{in.; say 20in.}$$

The cylinder volume per mile

$$= \left(\frac{20}{12}\right) \times \frac{\pi}{4} \times \frac{26}{12} \times 4 \times \frac{5280}{6.75 \times \pi} = 4709 \text{ cu. ft.}$$

	Cylinders.	Diameter of driving wheels.	Cylinder capacity.	Heating surface.	Grate area.	Load on driving wheels.	Steam pressure.	Grate area factor.	Adhesion factor.
	in.	ft. in.	cub. ft.	sq. ft.	sq. ft.	tons.	lb.		
Proposed engine	18 × 26	7 7½	3376	1500	22·5	18	180	150	0·68
Mr. Ivatt's No. 266*	18 × 26	7 7½	3376	1269	23·0	17¾	175	147	0·68
Mr. Dean's No. 3051 ...	19 × 24	7 8½	3436	1561	20·8	18	160	165	0·66

It is evident that these dimensions agree very favourably with current practice, and may be relied upon as a sound basis for a new design.

Example (*ii.*).—Next suppose a coupled engine (4–4–0) be required to give a tractive effort of 16,000 lb., the steam pressure to be 180 lb., the stroke to be 26in., and driving wheels 6ft. 9in. dia.

$$\text{Weight on driving wheels} = \frac{16{,}000}{450} \times 1.00 =$$

36·0 tons; that is, 18 tons per axle; the "Precursors" have 38 tons and the Midland Company's 990 has 38·7 tons, so 36 tons is assumed to be a suitable load.

The tractive force per pound of steam

$$= \frac{16{,}000}{0.75 \times 180} = 118.5 \text{ lb.;}$$

hence, diameter of cylinder will be

$$= \sqrt{\frac{118.5 \times 80}{26}} = 19.09\text{in., say 19in.}$$

Hence the heating surface = 4709 ÷ 2·25 = 2090 sq. ft., and the grate area required is 4709 ÷ 150 = 31·4 sq. ft.

	Cylinders.	Driving wheels, diameter.	Cylinder capacity.	Heating surface.	Grate area.	Steam pressure.	Tractive force.	Calculated weight on drivers.	Actual load on drivers.	Act. load / Cal. load	Cyl. capacity / Grate area.
	in.	ft. in.					lb.				
Proposed engine...	20 × 26	6 9	4709	2090	31·4	200	19,260	42·80	51	1·19	150
N.E. No. 2111	20 × 26	6 8	4769	1769	23·0	200	19,500	43·33	51·9	1·20	208
G.W. "Albions"	18 × 30	6 8½	4428	2143	27·0	225	20,370	45·28	54·2	1·20	164

A closer approximation could be obtained by a modification of the factors if it were thought necessary. The locomotive; but the same system of comparison can be extended to them, and will probably lead to similar results as obtained in the foregoing discussion.

The choice of examples depended upon the possession of the data relating to a series of consecutive designs, and doubtless the work of other locomotive designers would repay equally a detailed analysis.

ARMOURED CONCRETE TRUSSES.

WHILE armoured concrete has been used very extensively in the United States for bridge girders and in buildings, and even in viaducts, it has been used only to a limited extent for trusses. One of the few cases in which concrete truss spans have been employed is the Broadway bridge over the Cumberland River at Nashville. The river itself is crossed by three steel truss through spans—one of 320ft. and two of 178ft.—but the approaches consist of armoured concrete viaducts, with two concrete deck truss spans of 97½ft. and 91½ft. The panel length is 14ft. 11in. The horizontal bottom boom is 36in. wide and 18in. deep, while the curved upper boom varies from 36in. by 42in. at the end panels to 36in. by 38in. at the middle panel, where the depth is 16ft. between centres of booms. The truss posts are rounded off at top and bottom to form curved connections with the booms, and in line with them are upper posts, which rest on the upper boom and support the concrete floor of the bridge. It is to be noted that there are no diagonal members in the trusses. The section of the upper boom and the area of steel in the lower boom were arrived at by assuming the trusses fully loaded, with dead and live load and impact allowance, all applied at the panel points. The height between centres of booms was so made as to keep a constant tension in the lower boom. The upper boom was calculated also under the excentric loading as an equilibrated arch rib hinged at the ends, and under this assumption (due to the large dead load) the stresses on extreme fibres of the concrete are well within the crushing strength of concrete. The bridge is designed to carry a double line of electric tramway, with 40-ton motor cars and 30-ton trail cars.

THE ROYAL COMMISSION ON CANALS AND WATERWAYS.

No. XVI.*

FORTH AND CLYDE SHIP CANAL SCHEMES.

THE Royal Commission on Canals and Waterways concluded the taking of evidence by devoting the last two days of the public sittings to the consideration of proposals for the construction of a ship canal between the Forth and the Clyde. In this—the last of our series of articles summarising the evidence—we propose to deal with the question of the proposed Forth and Clyde Ship Canal, a subject which was considered by the Commission in 1907, when a number of witnesses were heard, and again, as we have already stated, at the two final sittings in April of this year.

Two distinct proposals for the construction of a ship canal have been made, each with one or two variants in detail. The first is commonly known as the direct route, and dates from over half a century ago, when proposals were made for the construction of a ship canal of some sort between the Forth near Grangemouth and the Clyde below Glasgow. This scheme was revised and enlarged in 1890, when a preliminary survey of the route was made by Messes. Crouch and Hogg, of Glasgow. After a further period of quiesence, the proposals were revived in 1903, when Mr. W. T. Douglass, of Westminster, made a survey, and prepared a scheme for a canal to follow much the same route as that originally proposed, but embodying considerable modifications in details. Both Mr. Hogg and Mr. Douglas appeared as witnesses before the Commission, the latter putting forward a revised scheme for a canal of greater dimensions than has ever before been proposed for the direct route.

The second proposal is that concerned with the Loch Lomond route suggested, we believe, in the first instance by Smeaton who made a survey in 1764. Smeaton's proposals were for a canal of very moderate dimensions, in fact, hardly more than a barge canal. About 1889 Mr. D. A. Stevenson, of Edinburgh, made another survey of the Loch Lomond route, and prepared the scheme which in a somewhat modified form has been submitted by him to the Royal Commission and supported by the evidence of Sir John Jackson and others.

At the present time there exist two canals connecting the east coast of Scotland with the west, viz., the Forth and Clyde barge canal from Grangemouth to Bowling, in the Clyde, opened in 1790, and now owned by the Caledonian Railway Company, and the other from Inverness to Fort William, known as the Caledonian Canal, which was constructed at National expense and is controlled by Government commissioners. We have described both these canals in earlier articles on this subject.† The Caledonian Canal is capable of passing vessels 160ft. long, 38ft. beam, and drawing 14ft.; while the Forth and Clyde Canal can take only barges of moderate dimensions.

The construction of the Rosyth naval base in the Firth of Forth has given renewed life to the proposals for a ship canal across Scotland, and the principal arguments in favour of its construction are now based, not on the commercial advantage, which undoubtedly would be considerable, but upon the strategic advantage of such a waterway in time of war. In recent times the problem of the maintenance of sea power has shifted its base from the English Channel and the Straits of Dover to the North Sea, and the growing strength of the German navy is an ever increasing argument in favour of the provision of rapid means of communication for battleships between the North Sea and the West Coast. It seems obvious that the strategic value of a ship canal would be so great as to justify the expenditure of a considerable sum to secure a waterway of sufficient dimensions to meet the needs of the Navy. The canal would form a link between the naval base in the Firth of Forth and the shipbuilding and engineering yards on the Clyde, which in time of war must be of vast benefit to the fleet. The advantage of rapidly moving a powerful squadron from one sea to the other in case of necessity without having recourse to the long and possibly impeded voyage through the Pentland Firth or the Straits of Dover is one which cannot be gainsaid. The saving in distance alone would be about 500 miles. The canal would also, in time of war, double the mobility of our fleet, giving us a power of concentration in the Atlantic or North Sea which would be denied to our opponents. The present intentions of the Government with regard to Rosyth include the building of one large graving dock in addition to the large entrance lock, which will be available as a dry dock, but it cannot be argued that this provision—no doubt sufficient for overhaul and repairs in peace times—will be an adequate provision for the needs of a fleet in the event of a naval war in the North Sea. On the other hand the canal would put the great shipbuilding and repairing facilities of the Clyde and other West Coast ports into immediate connection with the North Sea base. An objection, which has been raised on strategic grounds, to the construction of the canal applies equally to the provision of a naval base at Rosyth, and that is the possible destruction of the Forth Bridge in time of war, but this argument has no strong evidence to support it; the great depth and width of the channel at the Forth Bridge make the possibility of serious obstruction very remote, and at all events the argument has not been considered of sufficient importance by the naval authorities to prevent the construction of the Rosyth works.

From the commercial standpoint it must be admitted at the outset that there is little prospect of a canal large enough to accommodate modern battleships, paying a return upon the great outlay involved. Mr. Stevenson has put before the Commissioners a statement of estimated traffic which is certainly optimistic both as regards the volume and the rate of dues which would be levied on ships using the waterway. So far as we have been able to ascertain, few authorities other than Mr. Stevenson go to the length of anticipating a revenue sufficient to pay a moderate interest on the capital necessary to build the canal. It is significant that the Commissioners have been unable to obtain any evidence from the Corporation of Glasgow to the effect that financial support from the local authorities concerned would be forthcoming in the event of the construction of the canal, and, as a matter of fact, the Glasgow Chamber of Commerce has recently adopted a resolution setting forth the opinion that the scheme cannot be regarded as financially sound from a commercial point of view.

Taking the longer of the canal routes proposed—that by way of Loch Lomond—the mileage saved by vessels using the cana on voyages from North Sea ports to the West Coast and America is shown in the accompanying table:—

	Distance saved in nautical miles.
Aberdeen to Glasgow	320
Leith to Glasgow	485
Tyne to Glasgow	386
London to Glasgow	253
Hamburg to Glasgow	312
Baltic to Glasgow	242
Forth to Liverpool	400
Forth to Belfast	377
Forth to New York	175
Rotterdam to Glasgow	290
Amsterdam to Glasgow	377

By the "direct" route the savings in distances are somewhat greater.

The estimates of probable traffic, so far as they were put before the Commissioners by Mr. Stevenson, may be summarised as follows:—The witness bases his calculations on the Board of Trade shipping returns for 1907. He estimates that nearly 4½ millions registered tons of foreign-going shipping would find it advantageous to use the canal, as well as over 6¼ millions of tons of coasting traffic, or one-eighteenth part of the total of such traffic. Adding these figures together, he estimates that the total traffic of the canal will be 11,181,636 tons annually, yielding an average toll of 1s. 6d. per ton, or an income of £833,622. Deducting the cost of maintenance, which he puts at £50,000, he obtains a net revenue of £778,622, which would pay about 3¾ per cent. on 20 millions of capital expenditure. To say the least, Mr. Stevenson's figures are optimistic, and the suggested toll of 1s. 6d. per registered ton is out of all proportion to the rates charged on the Suez and Kiel Canals.

So far, we have dealt with aspects of the question which are to a great extent common to both of the proposed schemes. We now propose to refer to the details, taking first of all the Grangemouth-Yoker or direct route.

The scheme put before the Commissioners in 1907 by Mr. Hogg provides for a canal from Grangemouth to Yoker, in the Clyde, a distance of about 30 miles. The waterway would be 100ft. in width and 26ft. deep, with a summit level of 95ft. above mean sea level, and twelve locks in all, six on each side of the divide. Mr. Hogg estimated the cost of this canal at £7,000,000. The dimensions of the locks proposed are: Length 600ft., width 65ft.

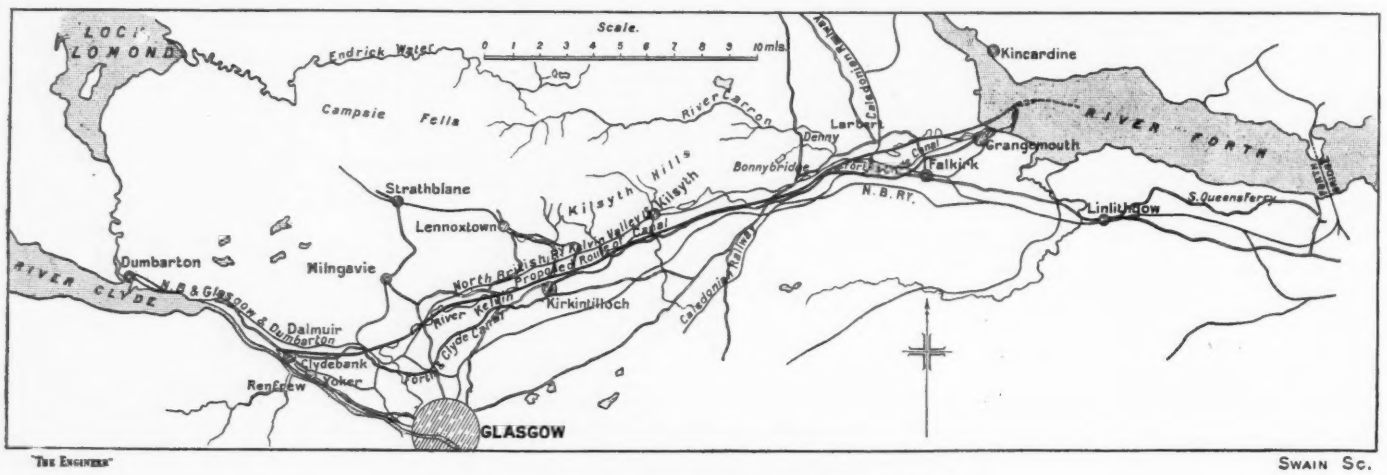


Fig. 1—PROPOSED FORTH AND CLYDE CANAL—DIRECT ROUTE

The scheme prepared by Mr. Douglass in 1904 provided for a canal following much the same route as in Mr. Hogg's proposal, commencing a little to the north of Grangemouth and following the north bank of the river Carron as far as Carronshore, where the river would be crossed for the first time. The route passes near the Carron Ironworks and to the south of Larbert, near which town the Caledonian Railway from Larbert and the Denny branch of the same railway would cross, to Bonnybridge. From Bonnybridge the line is generally parallel to the old Forth and Clyde Canal, passing the Bankier Distillery and to the south of Kilsyth to Kirkintilloch. Thence it follows the valley of the Kelvin to Garscube Bridge. To the west of the bridge the Forth and Clyde Canal is crossed. Leaving the Old Canal the line passes over country having a steep declivity towards the Clyde and terminates in the new dock of the Clyde Trustees between Yoker and Clydebank; the total length to this point from low water at Grangemouth being about 29 miles 4½ furlongs. The whole of the existing railways, other than the two lines at Yoker, viz, the Glasgow, Yoker and Clydebank Railway and the Lanarkshire and Dumbartonshire Railway, would be carried over the canal by high-level bridges giving a clear headway of not less than 75ft. for the passage of ships. The construction of these bridges would entail considerable railway deviations and alterations in alignment. The railways at Yoker are at such levels that there it would be impracticable to carry them over the canal except by means of a swing bridge, but a short diversion would enable both lines to be dealt with by one swing span. The road bridges and road deviations necessitated by the construction of the canal offer no insuperable difficulties.

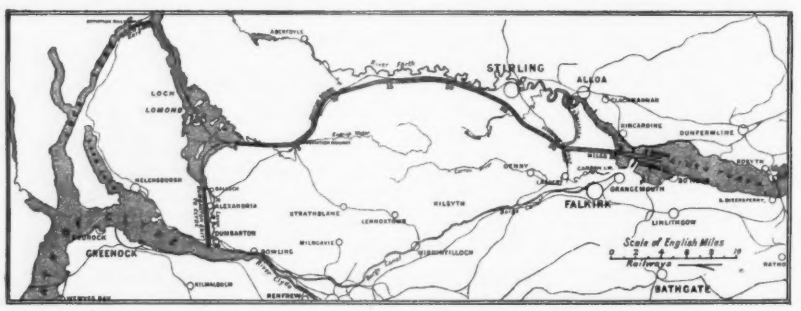


Fig. 2—PROPOSED FORTH AND CLYDE SHIP CANAL—LOCH LOMOND ROUTE

The excavation throughout would be in alluvial deposits and boulder clay, except in the neighbourhood of Kilsyth, where an outcrop of basalt would have to be cut through. Mr. Douglass estimates the total

* No. XV. appeared November 12th.
† THE ENGINEER, July 31st, 1908.

volume of the excavation necessary at nearly 66,000,000 cubic yards. The scheme provides for a waterway 30ft. deep and 130ft. in width at bottom, with locks 700ft. long, 80ft. wide, and 30ft. deep. The canal would have six sets of locks on either side, in addition to tidal regulating locks at the terminals. In addition to the large locks, there would be a smaller lock at each lift for vessels of moderate size, and the large locks would have intermediate gates. The summit level of nearly 19 miles would be 110ft. above Ordnance Datum. The question of water supply is one which closely affects any proposal for the construction of a high-level canal between the Forth and the Clyde; the supply to be obtained from the small streams in the neighbourhood of the canal summit is insufficient for the working of the canal, and Mr. Douglass proposes to draw an additional supply from the watersheds of the Endrick and Carron to the north of the Kilsyth Hills. The depth at low water in the Forth at Grangemouth is considerably less than the 30ft. intended in the canal, and to provide access to the locks from the deep water of the firth, training walls would have to be constructed at Grangemouth and an entrance channel dredged between them. Mr. Douglass' estimate of cost for the scheme sketched above is 10 millions sterling. His later proposal for a waterway on a larger scale which was put before the Royal Commission is estimated to cost 14 millions. In its revised form the scheme provided for a canal 140ft. in width at bottom, 35ft. deep, with only six sets of locks, three on either side, in addition to tidal locks at the terminals. The summit level proposed by this scheme is 95ft. above Ordnance Datum, or 85ft. above high water in the Forth, so that the lift from high-water level to the summit would be effected by means of three locks. The large locks are 1000ft. long, 110ft. wide, with 40ft. depth over sills. The minimum headway under bridges is put at 120ft. Mr. Douglass also proposes an alternative outlet for the canal into the Clyde. This question of the Clyde connection is the most difficult problem which would be met with in the course of construction of the work. Clydebank, Yoker, and the neighbourhood are so much built over, and land is so valuable, that the selection of a suitable route presents great difficulties. As the termination of the canal in the Clyde Trustees' Dock at Yoker, may be considered open to objection, Mr. Douglass suggested a deviation from the original proposal from the 27½ mile point, following the existing Forth and Clyde barge canal to 30 miles, passing to the south of the Kilbowie factory. At 30 miles the canal would cross the main Dumbarton-Glasgow road, and the line of the Lanarkshire and Dumbartonshire Railway, both of which would be diverted for the purpose. Thence the canal would enter the Clyde near Dalmuir light, nearly 30½ miles from the commencement. This revised scheme for a canal by the direct route has been prepared in view of the probable demands of the Admiralty, in the event of its construction. A depth of 35ft. would be required in order that damaged battleships drawing more than the normal might be passed through. With a view to a still greater depth being available if required, the locks would be constructed with 40ft. of water over sills. The estimate for this scheme is £14,000,000, including over five millions sterling for the excavation of 81 millions of cubic yards of material.

The witness also prepared an estimate of the cost of constructing a sea-level canal between the Forth and Clyde, following the same route as the high-level canal. The sea level construction entails an enormous increase in the volume of excavation—about 174 millions of cubic yards additional—but at the same time the expenditure on locks and water supply is reduced, and in some respects the difficulties of railway crossings are simplified. The dimensions of the waterway would be the same as in the fourteen millions scheme, but the minimum headway under bridges is increased to 130ft. The only locks would be regulating, or tidal locks, at Grangemouth and on the Clyde. The minimum water level throughout would be 7ft. above Ordnance Datum, or about the level of high water of neap tides in the Firth of Forth. The maximum depth of cutting would be between the thirteenth and fourteenth mile, where the land rises to 200ft. above Ordnance Datum. The cost of this scheme is put at a total of twenty-three millions sterling.

In all the estimates of cost of constructing a canal by this route, including that of Mr. Hogg, no provision has been made for the deepening of the Clyde from Yoker or Dalmuir to the sea. The present minimum depth at low water of spring tides is about 23ft., and the spring rise at Glasgow being about 11ft., the existing depth at high water is 34ft. It is, however, proposed still further to deepen the canal until 30ft. is available at low water, and it is reasonable to suppose that this depth would be provided by the Clyde Trustees in the event of a ship canal being constructed.

The advantages of the direct route over the Loch Lomond route are, first of all, the saving in distance. The first is less than 30 miles from Grangemouth to Yoker, while the second involves 40 miles of cutting, in addition to the deepening of the Forth from Grangemouth to the canal entrance, and the total length of the navigation between the Forth and the mouth of Loch Long is 68¼ miles. The distance from Grangemouth to the mouth of Loch Long by the direct route is about 48 miles, and to Dumbarton 38 miles. The cutting for the direct canal would be principally in soft material; on the other hand, the Loch Lomond scheme entails a vast quantity of rock cutting. Again, the direct route possesses the important advantage of passing through a manufacturing district and a valuable coalfield, thus bringing a number of large ironworks and collieries into direct communication with the sea. On the other hand, the difficulties connected with the Clyde junction at or below Yoker are considerable; an adequate water supply for a high-level canal entails a large additional expenditure, and some of the land to be acquired is of high value. Objections have also been made to the high-level scheme on the score of locks, but in any case terminal locks will be necessary, and the disadvantages connected with a moderate number of locks are probably exaggerated. The *pros* and *cons* of a lock canal compared with a sea level canal have been fully thrashed out in connection with the Panama Canal, with the result that the objections to their use in that waterway have not been considered of sufficient moment to justify the additional cost involved by sea level construction. In any case, the time involved in passing the additional locks on the high-level route cannot equal the delay occasioned by the extra mileage of the Loch Lomond route. Still another objection levelled against the direct route is the navigation of the Clyde between Yoker and Dumbarton. The river is in places not more than 400ft. wide, and the fear has been expressed that the traffic in the waterway might become congested. This is a point of considerable moment, and one upon which there is much diversity of opinion.

We now come to the details of the Loch Lomond scheme as put before the Commissioners in its revised form, which differs materially from the scheme outlined to them in 1907. The latter was estimated to cost seventeen millions, while the revised scheme is expected to cost about twenty millions. In order to avoid the necessity of swing bridges to carry several of the lines of railway over the canal the later scheme provides for constructing the eastern entrance to the canal in the Firth of Forth, a little to the north of Grangemouth, instead of at Alloa. By leaving the Forth 4½ miles below Alloa the Caledonian Railway can be carried over the canal at a point north of Larbert by a fixed bridge giving 120ft. headway. Thence the route proceeds by Stirling and Balfron station, where another high-level bridge would carry the railway over the canal, to Loch Lomond. From Loch Lomond to the sea there are two alternative routes proposed, one at the south end of the Loch from Balloch to the Clyde at Dumbarton, and the other further north, giving an exit from Loch Lomond into Loch Long by way of Tarbert. At a point 10 miles east of Loch Lomond the line passes through a hilly district, the level being 260ft. over sea level, falling gradually to the level of Loch Lomond, 22ft. above mean sea, which is proposed to be the level of the canal water surface throughout. The canal, which, as we have stated, is estimated to cost a little over twenty millions, would have a depth of 36ft.; but if a depth of 31ft. is considered sufficient, Mr. Stevenson reduces his estimate by two millions. He proposes a bottom width of 100ft., with eight passing places in 37½ miles. If the engineer's estimate of probable traffic is ever realised, there is little doubt that the passing places will have to be considerably increased in number or the canal much widened throughout. The entrance to the canal at both ends would be by means of locks, two lifts at each end. The total distance from the Firth of Clyde at the mouth of Loch Long is 68½ statute miles. Of this distance 28½ miles is made up of Loch Lomond and Loch Long, so that the actual canal cutting would be 40 miles, in addition to nearly four miles of dredging in the Firth of Forth. The length of the route *vid* Balloch and Dumbarton is 7½ miles less than the Tarbert-Loch Long route; but, on the other hand, the canal cutting between Balloch and Dumbarton is three to four miles longer, and the river between Dumbarton and the mouth of Loch Long is crowded with traffic. On the whole, Mr. Stevenson prefers the Loch Long route. The routes of the two rival schemes are shown in the plans—Figs. 1 and 2.

INSTITUTION OF MECHANICAL ENGINEERS.

Two papers were read and discussed at last Friday's meeting of the Institution of Mechanical Engineers, the titles being "Mild Steel Tubes in Compression and under Combined Stress" and "Compound Stress Experiments." The former was read by Mr. W. Mason, of the University of Liverpool, and the latter by Professor C. A. M. Smith, of the East London College. An abstract of Mr. Mason's paper is given on page 671. At the opening of the meeting Mr. J. A. F. Aspinall, who occupied the chair, announced that Professor Unwin and Mr. Robert Matthews had been appointed to fill the vacancies on the Council caused by the retirement of Mr. George Whale and Mr. J. F. Robinson, which take place at the end of the year. It was also announced at the close of the discussion that the next annual summer meeting would take place in conjunction with the American Society of Mechanical Engineers. The discussion was an exceptionally short one, which was due to the fact that after the papers had been read little more than half an hour remained before the time arrived for the meeting to be brought to a close.

Mr. J. J. Guest, of Birmingham, who was the first speaker, said that he did not consider that the authors had explained the general aim they had in view with sufficient fulness. The reason why he expressed that opinion was that after reading a paper on similar work he found that many of his audience had failed to catch the general drift of the paper. If a specimen were put in an ordinary testing machine and pulled it would break at so many pounds per square inch. A tension member in a bridge could be directly compared with the result of that test. In the case of a piece of mild steel in an unstayed boiler there was a hoop stress round the boiler and a longitudinal stress also. The material was therefore subjected to tension in two directions at right angles. Ordinary experiments in a testing machine gave no clue as to whether the second tension affected the capacity of the material to withstand the first tension. The questions which the experimenters were endeavouring to solve were: Could the effect of the tension on the resistance of the material be ascertained, and would the second stress lower the capacity of resistance of the material? They were the questions which the experimenters were endeavouring to answer.

In the case of the crank shaft to which Professor Smith referred, and to the solution of which problem his research was specifically directed, the second stress was of the opposite nature to the first; that was to say, if one was a tension stress the other would be a compressive stress, and *vice versâ*. The experiments which he, the speaker, had carried out, had convinced him that for ductile mild steel the shearing stress was the governing factor. Professor Smith and Mr. Mason had extended the research to the unexplored region. He would first deal with Mr. Mason's experiments. He wished to criticise Figs. 15 and 16 in Mr. Mason's paper, as he did not think that they represented matters quite fairly. Mr. Guest then proceeded to draw on the blackboard the diagram shown in Fig. 1. Mr. Mason, he said, had tested the material in axial tension, and had found it to give a certain point A. He had also carried out experiments corresponding to the boiler plate, and had subjected the test pieces to equal tension, both longitudinally and laterally, obtaining the point B, the yield point for combined axial and hoop tension. If tension were put on the material up to a point C, then tension in a perpendicular direction could be put upon the material up to the amount A B before the material yielded. With the amount C D the material would not yield. The new tension in a direction at right angles to the first would

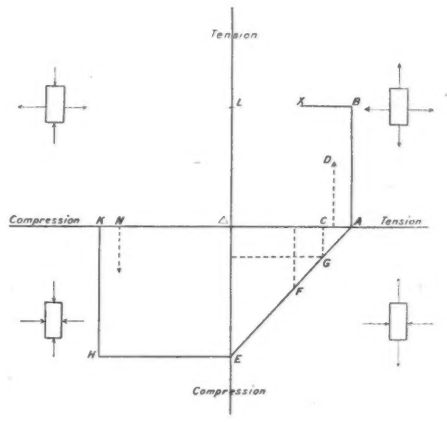


Fig. 1

not affect the capacity of the material to withstand the first. In dealing with combined tension and compression stresses, Mr. Mason had put the material in pure compression and obtained a point at E showing the yield point. Then he had taken a certain tension, combined with an equal amount of compression, finding that he could only apply little more than half the previous stresses obtaining at the point F. The stress in the material in that case was a pure shear stress. The second stress then did have a great effect upon the capacity of the material to resist the first stress. If he had put on stresses equivalent to three-quarters tension and one compression, &c., he would have obtained nearly a straight line E A, but that line had been fully obtained by Professor Smith in an entirely different way. To get the point H, Mr. Mason had applied a compression O E in one direction, and an equal compression E H in a direction perpendicular to it. That was the opposite to the case of double tension—the point B. If the material yielded at K, and it were loaded up to E, it would be possible to go on loading it with a perpendicular compression almost up to an amount E H before the material yielded. Mr. Mason's research had located points B, A, F, E, H, but the speaker did not think that he should have duplicated the diagram by reflexion in the line B H. That might suggest that the material had had further tests applied to it, for the point K would correspond to compression in a direction perpendicular to the compression represented by B E—one would be hoop and the other lengthways compression—and similarly for the points A and L.

Professor Smith among others had criticised the use of tubes, but he, Mr. Guest, believed that they were suitable for some experiments. He fully recognised the great importancee of using solid specimens for certain experiments, but he considered that reliable and useful results could be obtained from tubes. His own research obtained a series of points running from A up to B and along B X towards the point L, and also from A towards F. That he considered the easiest part of the curve to obtain. The two extensions of the investigation were both exceedingly difficult pieces of work. Mr. Mason's achievement was to obtain the point H, whilst Professor Smith had covered by a number of points the line A E, which for the materials dealt with completely settled the vexed question of the crank shaft, and the portion of which from F to E was extremely difficult to determine. It appeared that the whole problem of compound stresses in mild steel had been fairly solved, although Mr. Mason should have filled in the line E H as completely as the figure had been filled in from E to A and B. It was fortunate that Professor Smith and Mr. Mason had attacked the problem from quite different standpoints. It would be noticed that the points of Mr. Mason's stress strain curve did not come so exactly on the mean curve as Professor Smith's points. That could be accounted for partly by the instability of the material under Mr. Mason's experiment—secondary flexure troubles—and partly because Professor Smith had aimed at a much higher precision in his observations, taking into account also the stress distribution, which he actually measured. He had no doubt that the axis of stress and that of the specimen were never really coincident, but in his own experiments he had done his best to make them so. The testing machine was not a precision tool,

but a weighing machine, and too much should not be expected from it.

Professor Smith had continued some of his—the speaker's—tests in relation to the amount of bending, and had stated that he—Mr. Guest—had not obtained a pure torque. The stops taking the lower bars, however, had been carefully set up in the various experiments, and almost the same arrangement of bicycle pulleys as Professor Smith used were employed. He did not think there was very much bending, and as a matter of fact, in his own experiments that had been guarded against. Drawing a sketch similar to that shown in Fig. 2, Mr. Guest went on to explain that the arrangement employed consisted of two mirrors mounted on the specimen, and

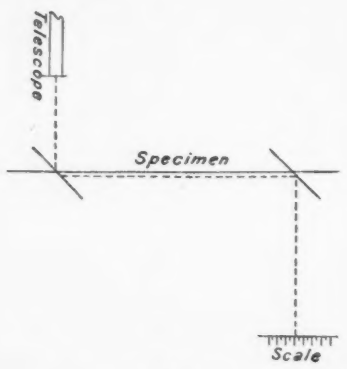


Fig. 2

inclined to its axis at angles of 45 deg. A telescope and scale were employed, and the line of sight followed the dotted line. If any bending occurred when the specimen was in tension or compression, the scale as seen through the telescope would appear to tilt forward or backward. In the majority of cases there was no bending, and where it was at all discernible a mark was put against the results. Professor Smith had criticised the use of tubes as specimens. In reply to those remarks he thought that the split collet arrangement would hold the tubes without undue distortion. In his own experiments he had used solder, and had not found that it injured the tube. Professor Smith had also stated that the material was not isotropic, but in his own experiments the tubes had been carefully selected, and their density precluded the existence of the defects known to occur in tube or wire-drawing. They were round, and of uniform thickness, and in no case were they seven-thousands of an inch out, as Mr. Mason's had been, but were less than one-thousandth out. The material from which the tubes were constructed were checked for isotropism by the method of applying the stresses, the material being first made to yield under stresses P_1 and P_2—as shown in Fig. 3—and then a test made with the values of P_1 and P_2

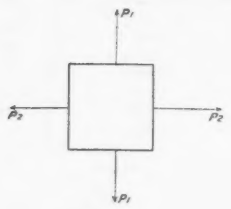


Fig. 3

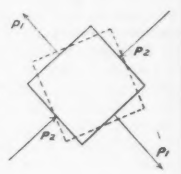


Fig. 4

interchanged. Also tests could be applied producing stresses such as P_1 and P_2 in Fig. 4, and other tests in which the sides of the element could have a different position as indicated by the broken lines. The difficulty of making accurate measurements of the specimens subjected to loads was overcome by weighing the tubes in air and in water, from which the volume and density were calculated. If there were flaws the density would be low. The tension tests were always found to give a high yield-point stress, which was also against the existence of flaws.

The chief point raised by Professor Smith was that tubes when loaded in compression might fail by reason of secondary flexure. Mr. Mason had experienced some trouble of that kind, but tests in which it occurred had, of course, to be rejected. In dealing with the last objection raised by Professor Smith with regard to the use of tubes, namely, that engineers did not seem to have confidence in tests carried out upon them, the speaker said that engineers knew the chances there were of getting flaws in cheaply made tubes, and so might be suspicious even of tests made on good tubes. Finally, in congratulating the authors on the work they had done, Mr. Guest said that probably both gentlemen had many serious drawbacks in the course of their experiments. That was more than probable in Professor Smith's case, for he dealt with refinements of measurement to a degree of $\frac{1}{100,000}$ of an inch on specimens under very high stresses. All engineers knew what patience, skill, and labour, measurements involving such an advance of precision meant. The audience listening to a paper and looking at a point on a curve probably did not fully realise that it took 70 observations or thereabouts to get it, and that possibly three or four months were occupied in getting the apparatus to work well. Although this extremely difficult work on mild steel was completed for stresses in two dimensions, he thought that it would be of scientific interest to have the results of some experiments on similar material under stresses in three dimensions. Practically yielding occurred at the surface of a body, the third stress being zero, or nearly so. It had long been known that cast iron gives way under tension only. It would, he thought, be of great interest to know what caused elastic failure in other materials used in engineering work. Was there an abrupt change or some continuous general law?

The next and last speaker was Mr. J. P. E. C. Stromeyer, who remarked that it would have been an advantage if Mr. Mason had given the hoop tension. That, he thought, would have made the paper more interesting, for it would have completed the curve. As he pointed out when he took part in the discussion of Mr. Izod's paper, every material has a characteristic of its own. Turning to Prof. Smith's paper, the speaker said that it seemed to him from the last four readings in the table on page 15 that the author inferred that so long as the ratio of maximum stress to mean stress did not exceed a certain value the material would not fail. If this were so the material could be stressed up to an infinite value without failure, provided that this ratio were not exceeded. At this point Professor Smith remarked that the speaker was drawing an erroneous conclusion, for the stresses on the third plane had to be borne in mind. Referring to Mr. Smith's sphingometer, the speaker said that it was his view, so far back as 1880, that several instruments should be employed to get the elastic limit. He had always used at least two instruments. In his tests in connection with Blackfriars Bridge he used four instruments, two at the top and two at the bottom. There was one objection to Mr. Smith's instrument, and that was that the coiled metal strip was not made of the same material as the metal undergoing test. He thought that the difference in the coefficients of expansion would have an effect upon the accuracy of the instrument. Both papers, he thought, gave insufficient details pertaining to the results. Mr. Mason gave twenty curves, whilst Mr. Smith only gave two, and Mr. Mason had omitted thirty-three curves that he should have included.

Professor Smith writes that as he had no opportunity to reply to the discussion on Friday night, he would like us to publish a few notes in order to make clear some points which evidently confused Mr. Guest. He states that as he was only permitted about twenty minutes to read his paper, he refrained from going over the ground already covered by his other papers, references to which were given. His object was to prove definitely the case of the crank shaft. Mr. Guest, he goes on to say, made experiments on tubes which suggested that mild steel does not fail in the manner as was until then supposed. Lord Kelvin, on the other hand, with evidence which Mr. Guest's experiments did not refute, previously made a statement which really meant that the shear stress theory of elastic limit was not correct. The experiments made at the East London College, it is pointed out, proved not that the shear stress theory was approximately correct, but that it was, for the S.S. mild steel used, correct to within very narrow limits. Mr. Guest's approximate results obtained with tubes were confirmed, and the tests made on specimens under combined compression and torsion proved the shear stress theory for mild steel. Our correspondent informs us that he made rough experiments with tubes, and abandoned them for accurate work.

The tubes used by Mr. Guest, he states, were made in America, and Mr. Guest acknowledged that the English made tubes contained blemishes such as to give rise to variations of .007in. in thickness, but the American tubes were quite free from such defects. Professor Smith is of opinion that tubes are probably satisfactory for quite approximate results, say to within 10 per cent., but he aimed at as great an accuracy as possible in order to test Navier's theory, for which approximate results would be of little value. He considers that, taking into account the labour involved in any work on compound stress, it is worth while aiming at great accuracy. The tests on the S.S. specimens, we are informed, gave experimental results, which almost coincided with the shear stress curve. All the published tests on tubes, we are told, contained certain results which had to be discarded, which fact alone, it is considered, showed how the material varied. The elastic breakdown of a tube in compression, it is maintained, cannot be located with any certainty because of secondary flexure. Professor Smith draws attention to the fact that Mr. Guest's work did not include compression tests, so essential for the case of the crank shaft. There are, he considers, certain cases of compound stress of academic, but no immediate practical interest which could be approximately solved if tubes were used; these, however, Professor Smith has not attempted to attack. Lastly, our correspondent expresses the opinion that the value of Mr. Guest's pioneer work cannot be overestimated.

MARCONI WIRELESS TELEGRAPHY.*

By Mr. G. Marconi.

No. II.*

A RESULT of scientific interest which I first noticed during the tests on s.s. Philadelphia, and which is a most important factor in long-distance radio-telegraphy, was the very marked and detrimental effect of daylight on the propagation of electric waves at great distances; the range by night being usually more than double that attainable during daytime.[1] I do not think that this effect has yet been satisfactorily investigated or explained. At the time I carried out the tests I was of opinion that it might be due to the loss of energy at the transmitter, caused by the dis-electrification of the highly-charged transmitting elevated conductor under the influence of sunlight.

I am now inclined to believe that the absorption of electric waves during the daytime is due to the ionization of the gaseous molecules of the air affected by ultra-violet light, and as the ultra-violet rays, which emanate from the sun, are largely absorbed in the upper atmosphere of the earth, it is probable that the proportion of the earth's atmosphere which is facing the sun will contain more ions or electrons than that portion which is in darkness, and therefore, as Sir J. J. Thomson has shown[2], this illuminated and ionised air will absorb some of the energy of the electric waves. Apparently, the length of wave and altitude of electrical oscillations have much to do with this interesting phenomenon, long waves and small amplitudes being subject to the effect of daylight to a much lesser degree than short waves and large amplitudes. According to Professor Fleming, the daylight effect should be more marked on long waves, but this has not been my experience. Indeed, in some very recent experiments, in which waves about 8000 m. long were used, the energy received by day was usually greater than at night. The fact remains, however, that for comparatively short waves, such as are used for ship communication, clear sunlight and blue skies, though transparent to light, act as a kind of fog to these waves. Hence, the weather conditions prevailing in England, and perhaps in this country (Sweden), are usually suitable for wireless telegraphy.

During the year 1902 I carried out some further tests between the station at Poldhu and a receiving installation erected on the Italian cruiser Carlo Alberto, kindly placed at my disposal by H.M. the King of Italy[3]—Fig. 15. During

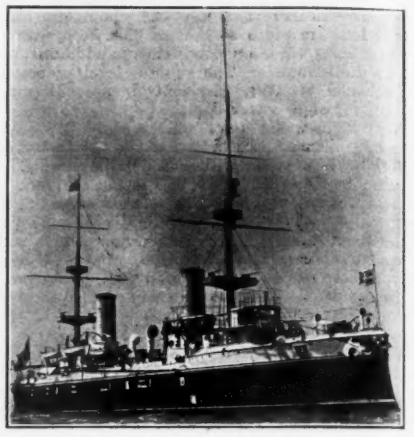


Fig. 15

these experiments the interesting fact was observed that even when using waves as short as 1000ft., intervening ranges of mountains, such as the Alps or Pyrenees, did not, during the night time, bring about any considerable reduction in the distance over which it was possible to communicate. During daytime, unless much longer waves and more power were used, intervening mountains greatly reduced the apparent range of the transmitter. Messages and press despatches of considerable length were received from Poldhu at the positions marked on the map, which map is a copy on a reduced scale of the one accompanying the official report of the experiments—Fig. 16.

With the active encouragement and financial assistance of the Canadian Government, a high-power station was constructed at Glace Bay, Nova Scotia, in order that I should be able to continue my long-distance tests with a view to establishing radio-telegraphic communication on a commercial basis between England and America.[4] On December 16th,

Fig. 16

1902, the first official messages were exchanged at night across the Atlantic, between the stations at Poldhu and Glace Bay—Figs. 17 and 18. Further tests were shortly afterwards carried out with another long distance station at Cape Cod in the United States of America, and under favourable circumstances it was found possible to transmit messages to Poldhu, 3000 miles away, with an expenditure of electrical energy of only about 10 kilowatts.

In the spring of 1903 the transmission of Press messages by radio-telegraphy from America to Europe was attempted, and for a time the London *Times* published, during the latter part of March and the early part of April of that year, news messages from its New York correspondent sent across the Atlantic without the aid of cables. A breakdown in the insulation of the apparatus at Glace Bay made it necessary, however, to suspend the service, and unfortunately further accidents made the transmission of messages uncertain and unreliable. As a result of the data and experience gained by these and other tests which I carried out for the British Government, between England and Gibraltar, I was able to erect a new station at Clifden in Ireland, and enlarge the one at Glace Bay in Canada, so as to enable me to initiate, in October, 1907, communication for commercial purposes across the Atlantic between England and Canada. Although the stations at Clifden and Glace Bay had to be put into operation

* No. I. appeared December 17th.

1 See Proceedings of the Royal Society, Vol. LXX., "A Note on the Effect of Daylight upon the Propagation of Electromagnetic Impulses." G. Marconi, June 12th, 1902.

2 See *Philosophical Magazine*, August, 1902, Ser. 6, Vol. IV., p. 253. J. J. Thomson, "On some Consequences, &c."

3 See "Revista Marittima," Rome, October, 1902.

4 See paper read before the Royal Institution of Great Britain by G. Marconi, March 3rd, 1905.

before they were altogether complete, nevertheless communication across the Atlantic by radio-telegraphy never suffered any serious interruption during nearly two years until, in consequence of a fire at Glace Bay this autumn, it has had to be suspended for three or four months. This suspension

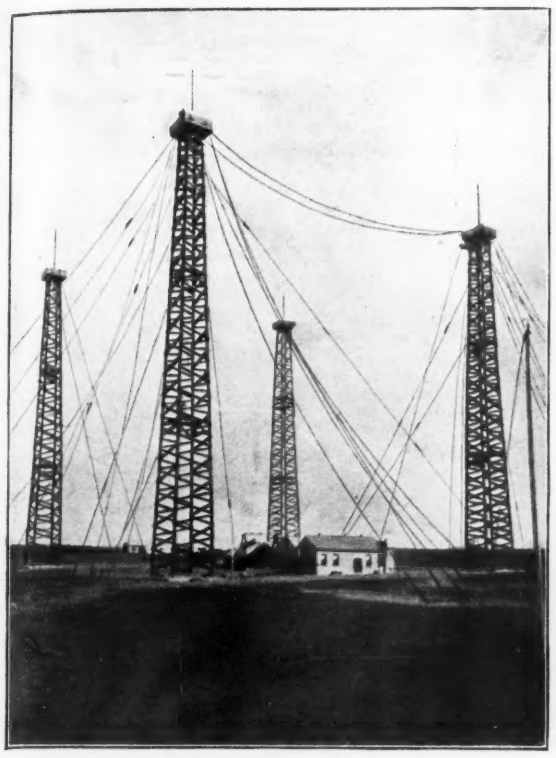


Fig. 17

has not, however, been altogether an unmitigated evil, as it has given me the opportunity of installing more efficient and up-to-date machinery.

The arrangements of elevated conductors or aerials which

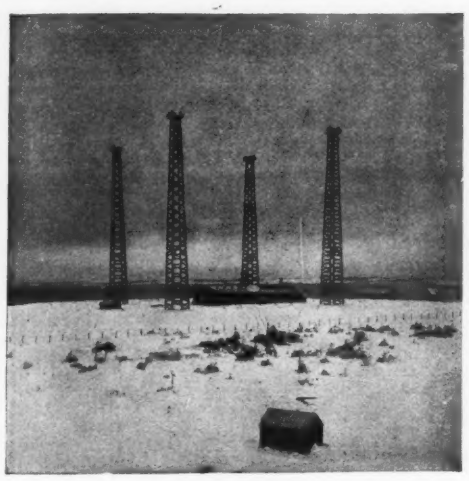


Fig. 18

I have tried during my long-distance tests are shown in Figs. 19, 20, and 21.[5] The aerial, shown in Fig. 21, consisted of a nearly vertical portion in the middle, 220ft. high, supported by four towers, and attached at the top to nearly

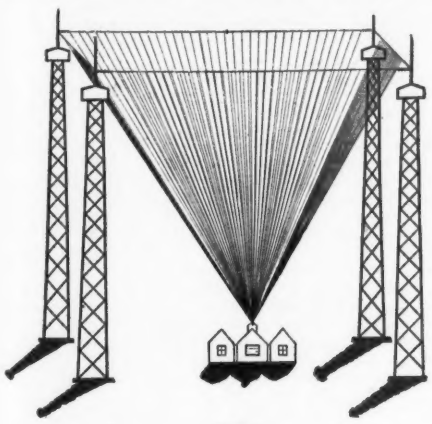


Fig. 19

horizontal wires, 200 in number and each 1000ft. long, extending radially all round, and supported at a height of 180ft.

[5] See also lecture before the Royal Institution of Great Britain by G. Marconi, March 13th, 1908.

from the ground by an inner circle of 8, and an outer circle of 16, masts. The natural period of oscillation of this aerial system gave a wave length of 12,000ft. Experiments were made with this arrangement in 1905, and with a wave length of 12,000ft., signals, although very weak, could be received across the Atlantic by day as well as by night. The system of aerial I finally adopted for the long distance stations in England and Canada is shown in Fig. 22. This arrangement not only makes it possible efficiently to radiate and receive waves of any desired length, but it also tends to confine the main portion of the radiation to a given direction. The limitation of transmission to one direction is not very sharply defined, but the results obtained with this type of aerial are nevertheless exceedingly useful.

Many suggestions respecting methods for limiting the direction of radiation have been made by various workers, notably by Professor F. Braun, Professor Artom, and Messrs. Bellini and Tosi. In a paper read before the Royal Society in London in March, 1906[6], I showed how it was possible by means of horizontal aerials to confine the emitted radiations mainly to the direction of their vertical plane, pointing away from their earthed end. In a similar manner it is possible to locate the bearing or direction of a sending station. The transmitting circuits at the long distance stations are arranged in accordance with a comparatively recent system for producing continuous or slightly damped oscillations, which I referred to in a lecture before the Royal Institution of Great Britain on March 13th, 1908. An insulated metal disc A— Fig. 23—is caused to rotate at a high rate of speed by means of an electric motor or steam turbine. Adjacent to this disc, which I will call the middle disc, are placed two other discs C′ and C″, which may be called polar discs, and which are also revolved. These polar discs have their peripheries very close to the surface or edges of the middle disc. The two polar discs are connected by rubbing contacts to the outer ends of two condensers K, joined in series, and these condensers are also connected through suitable brushes to the terminals of a generator, which should be a high-tension continuous current generator. On the middle disc a suitable brush or rubbing contact is provided, and between this contact and the middle point of the two condensers an oscillating circuit is inserted, consisting of a condenser E in series with an inductance, which last is inductively connected with the radiating antennæ. The apparatus works probably in the following manner:—The generator charges the double condenser, making the potential

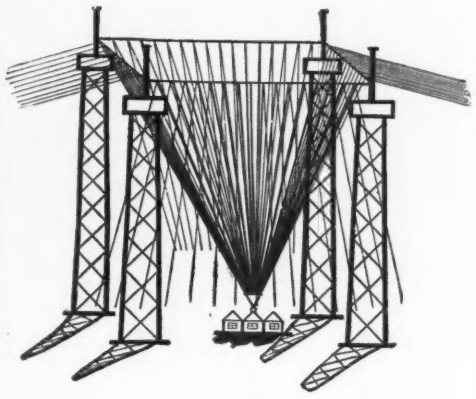


Fig. 20

of the discs, say, C′ positive and C″ negative. The potential, if high enough will cause a discharge to pass across one of the gaps, say, between C′ and A. This charges the condenser E through the inductance F, and starts oscillations in the circuit. The charge of F in swinging back will jump from A to C″, the potential of which is of opposite sign to A, the dielectric strength between C′ and A having meanwhile been restored by the rapid motion of the disc, driving away the ionised air. The condenser E therefore discharges and recharges alternatively in reverse directions, the same process going on so long as energy is supplied to the condensers K by the generator H. It is clear that the discharges between C′

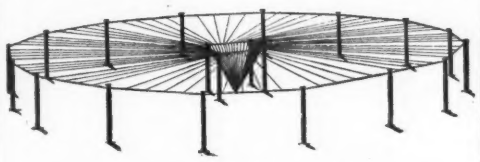


Fig. 21

and C″ and A are never simultaneous, as otherwise the centre electrode would not be alternatively positive and negative.

The best results have, however, been obtained by an arrangement, as shown in Fig. 24, in which the active surface of the middle disc is not smooth, but consists of a number of regularly spaced copper knobs or pegs, at the ends of which the discharges take place at regular intervals. In this way it is possible to cause the groups of oscillations radiated to reproduce a high and clear musical note in a

[6] "On Methods whe eby the Radiation of Electric Waves may be Mainly Confined, &c." "Proceedings" of the Royal Society, A Vol., 77, 1906.

receiver, and thereby it is easier to differentiate between the signals emanating from the sending station and noises caused by atmospheric electrical discharges. By this method very efficient resonance can be also obtained in appropriately designed receivers.

With regard to the receivers employed, important changes have taken place. By far the larger portion of electric wave telegraphy was, until a few years ago, conducted by means

Fig. 22

of some form or other of coherer, or variable contact either requiring tapping or self-restoring. At the present day, however, I may say that in all the stations controlled by my company my magnetic receiver is almost exclusively employed —Fig. 25[7]. This receiver is based on the decrease of magnetic hysterises which occur in iron when under certain conditions this metal is subjected to the effects of electrical waves of high frequency. It has recently been found possible to

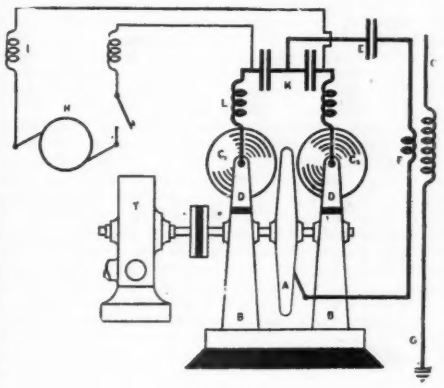


Fig. 23

increase the sensitiveness of these receivers, and to employ them in connection with a high-speed relay, so as to record messages at great speed.

A remarkable fact, not generally known, in regard to transmitters is that none of the arrangements employing condensers exceed in efficiency the plain elevated aerial or vertical wire discharging to earth through a spark gap, as used in my first experiments—Figs. 2 and 3 (*ante*). I have

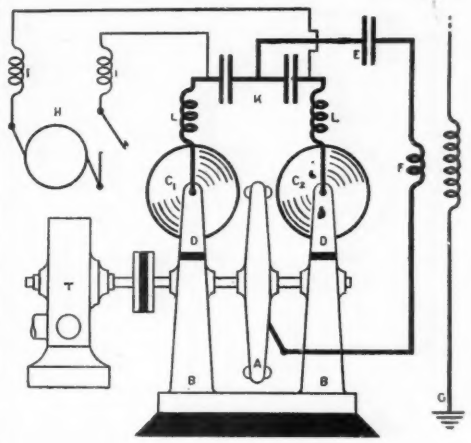


Fig. 24

recently been able to confirm the statement made by Professor Fleming in his book, "The Principles of Electric Wave Telegraphy," 1906, page 555, that with a power of 8 watts in the aerial it is possible to communicate to distances of over 100 miles. I have also found that by this method it is possible to send signals 2000 miles across the Atlantic with a smaller expenditure of energy than by any other method known to myself.

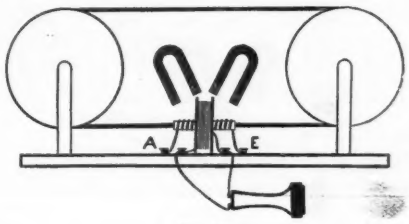


Fig. 25

The only drawback to this arrangement is that unless very large aerials are used, the amount of energy which can be efficiently employed is limited by the potential, beyond which brush discharges and the resistances of the spark gap begin to have a deleterious effect. By means of spark gaps in compressed air and the addition of inductance coils placed between the aerial and earth, the system can be made to

[7] "Proceedings" of the Royal Society. "Note on a Magnetic Detector of Electric Waves." G. Marconi, Vol. LXX., 1902, page 341.

radiate very pure and slightly damped waves, eminently suitable for sharp tuning. In regard to the general working of wireless telegraphy, the widespread application of the system and the multiplicity of the stations have greatly facilitated the observation of facts not easily explainable. Thus it has been observed that an ordinary ship station utilising about half a kilowatt of electrical energy, the normal range of which is not greater than 200 miles, will occasionally transmit messages across a distance of over 1200 miles. It often occurs that a ship fails to communicate with a nearby station, but can correspond with perfect ease with a distant one.

On many occasions last winter the steamship Caronia, of the Cunard Line, carrying a station utilising about half a kilowatt, when in the Mediterranean off the coast of Sicily, failed to obtain communication with the Italian stations, but had no difficulty whatsoever in transmitting and receiving messages to and from the coasts of England and Holland, although these latter stations were considerably more than 1000 miles away and a large part of the Continent of Europe and the Alps lay between them and the ship.

Although high power stations are now used for communicating across the Atlantic, and messages can be sent by day as well as by night, there still exist short periods of daily occurrence during which transmission from England to America, or *vice versâ*, is difficult. Thus, in the morning and evening, when, in consequence of the difference in longitude, daylight or darkness extends only part of the way across the ocean, the received signals are weak, and sometimes cease altogether. It would almost appear as if electric waves, in passing from dark space to illuminated space, and *vice versâ*, were reflected in such a manner as to be diverted from their normal path. It is probable that these difficulties would not be experienced in telegraphing over equal distances north and south, on about the same meridian, as in this case the passage from daylight to darkness would occur almost simultaneously over the whole distance between the two points.

Another curious result, on which hundreds of observations continued for years leave no further doubt, is that regularly, for short periods, at sunrise and sunset, and occasionally at other times, a shorter wave can be detected across the Atlantic in preference to the longer wave normally employed. Thus, at Clifden and Glace Bay, when sending on an ordinary coupled circuit arranged so as simultaneously to radiate two waves, one 12,500ft. and the other 14,700ft., although the longer wave is the one usually received at the other side of the ocean, regularly about three hours after sunset at Clifden and three hours before sunrise at Glace Bay the shorter wave alone was received with remarkable strength, for a period of about one hour. This effect occurred so regularly that the operators tuned their receivers to the shorter wave at the times mentioned as a matter of ordinary routine.

With regard to the utility of wireless telegraphy, there is no doubt that its use has become a necessity for the safety of shipping, all the principal liners and warships being already equipped, its extension to less important ships being only a matter of time, in view of the assistance it has provided in cases of danger. Its application is also increasing as a means of communicating between outlying islands, and also for the ordinary purposes of telegraphic communication between villages and towns, especially in the Colonies and in newly developed countries. However great may be the importance of wireless telegraphy to ships and shipping, I believe it is destined to an equal position of importance in furnishing efficient and economical communication between distant parts of the world, and in connecting European countries with their Colonies and with America. As a matter of fact, I am at the present time erecting a very large power station for the Italian Government at Coltano, for the purpose of communicating with the Italian Colonies in East Africa, and with South America.

Whatever may be its present shortcomings and defects, there can be no doubt that wireless telegraphy even over great distances has come to stay, and will not only stay, but continue to advance. If it should become possible to transmit waves right round the world, it may be found that the electrical energy travelling round all parts of the globe may be made to concentrate at the antipodes of the sending station. In this way it may some day be possible for messages to be sent to such distant lands by means of a very small amount of electrical energy, and therefore at a correspondingly small expense. But I am leaving the regions of fact, and entering the regions of speculation, which, however, with the knowledge we have gradually gained on the subject, promise results both useful and instructive.

A NEW CABLE SHIP.

A NEW twin-screw cable-repairing steamer named Telconia, built by Swan, Hunter and Wigham Richardson, Limited, of Walker and Wallsend-on-Tyne, has recently been completed to the order of the Telegraph Construction and

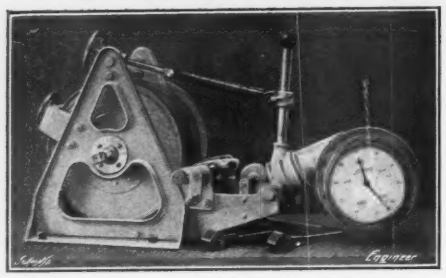


Fig. 1—LUCAS AUTOMATIC SOUNDING MACHINE

Maintenance Company, Limited. The principal dimensions of the Telconia are:—Length over all, 223ft.; breadth, 30ft. 9in.; and depth moulded, 21ft. 6in. At Lloyd's low draught she has a total deadweight capacity of 1000 tons. She is provided with triple expansion engines and two single-ended boilers with forced draught, and when indicating 1050 horse-power her speed is 12 knots. On page 664 is given a picture of the vessel when on trials off Tynemouth. The hull, engines, and boilers were built at the Neptune Works of Swan, Hunter and Wigham Richardson, Limited, but the cable machinery and appliances were designed and manufactured by the Telegraph Construction and Maintenance Company, Limited, whilst the general arrangement of the ship in all its details was carried out in accordance with the designs of Mr. F. R. Lucas, the managing director of the owning company.

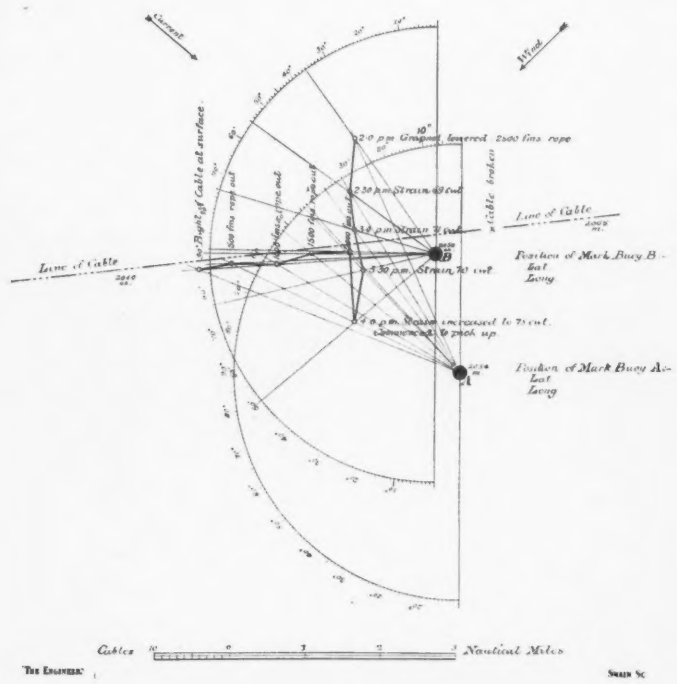

Current
Wind
2·0 p.m. Grapnel lowered 2500 fms rope
2·30 p.m. Strain 69 cwt.
3·0 p.m. Strain 71 cwt.
3·30 p.m. Strain 70 cwt.
4·0 p.m. Strain increased to 75 cwt. commenced to pitch up
Line of Cable
Position of Mark Buoy B—last Lwng
Position of Mark Buoy A—Last Lwng
Cables
Nautical Miles

Fig. 2—GRAPPLING CHART

One special feature of the Telconia is that the crew are

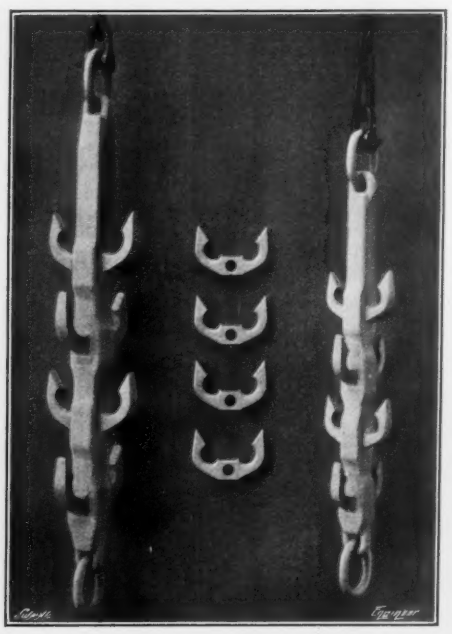


Fig. 3—CENTIPEDE GRAPNEL

quartered aft, and the whole of the space forward of the bridge is set aside for cable work. The captain's cabin is on the bridge deck, and the officers' cabins and the saloon are situated amidships. The sailors and firemen are provided

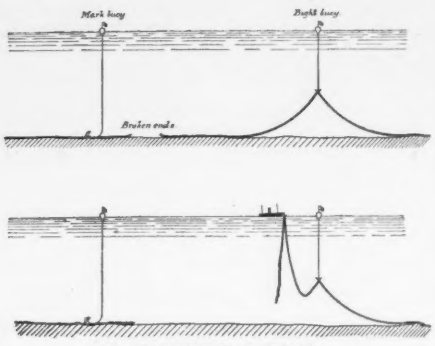


Fig. 4—BUOYING A CABLE

with quarters in the after 'tween decks, while the petty officers — including boatswain, carpenter, foremen cable hands, and quartermasters—find comfortable accommodation in the after deck-house.

The duplex picking-up machinery occupies the centre of the space in the forward 'tween decks. The gear is controlled from the upper deck, from which place the attendant has the whole of the cable operations under his observation. Three views on page 664 show the picking-up machinery and the inboard and outboard side of one of the picking-up machines, both the latter views having been taken in the works of the Telegraph Construction and Maintenance Company, Limited, prior to the erection on board the ship. The electrical testing-room is situated under the bridge amidships, and from this apartment the electrician is enabled to view the whole of the cable operations. The bow sheaves, which are constructed of cast steel, are wide and flat in the tread, and thus permit of an ordinary centipede grapnel being hove right inboard. At the sides of the 'tween decks there are placed grapnels, coils of rope, and all the other tools most generally used in cable work. The buoys are stored in the forehold immediately under derricks, by means of which latter they are lifted into the fore-rigging in the required positions for launching. The grapnel ropes, buoy moorings, and chains are also conveniently placed so as to be readily led on to the gear for paying-out purposes. There is a total coiling space in the two cable tanks of about 8000 cubic feet. The upper deck is constructed of steel, sheathed with Oregon pine, and has the usual camber of about 6in., whilst the main deck is flat and forms a good bed for bolting down the picking-up machinery, besides providing lofty 'tween decks. The main deck is constructed of steel covered throughout with Lito-silo, which provides a warm and non-slipping surface. The boats are carried in Welins' patent davits.

Some brief outline of the *modus operandi* pursued in repairing submarine cables, for which the vessel has been specially designed, may not be without interest to readers of this journal. First, the electrician determines, by means of careful electrical measurements taken from the shore, the position of the fault in the cable. The ship then proceeds to the spot and places a mark-buoy as nearly in the position as can be estimated, and, whilst waiting to verify it by astronomical observations, she takes a series of soundings so as to determine accurately the depth and nature of the bottom in the neighbourhood of the buoy, where the grappling work will have to be done. The soundings are taken with a wire sounding machine. The wire is on a cast steel drum, and as it is paid out passes over a measuring wheel, the revolutions of which record on a dial the number of fathoms out. A spring brake, which is capable of stopping the reel

Fig. 5—CUTTING AND HOLDING GRAPNEL

instantly, is kept out of action by the tension of the wire during the run out, but when the sinker strikes the bottom the loss of tension allows the brake to spring back and stop the reel. The depth can then be read off on the dial (Fig. 1). The wire is wound in by a small engine or by a messenger from the steam winch. On obtaining the latitude and longitude by observation, it may be found that the mark buoy is some distance from the line of cable, in which case a second buoy would be placed exactly on the line, and the bearings of both buoys would be used in order to determine the courses made whilst grappling. The ship now proceeds to the position for lowering the grapnel, which is usually about a mile from the line of cable, and she then steams very slowly across the cable. The speed of grappling should never exceed one mile per hour, and in deep water it is often advantageous not to go more than half this speed. The ship is sometimes allowed to drift with the wind or current when these are favourable, and across the line. The whole operation may be seen by reference to Fig. 2, which is a reproduction of a real chart.

After the cable has been hooked and raised to the surface, it is cut, and the ends taken on board the repairing ship. Electrical tests are then taken to ascertain towards which shore the fault lies and how far from the ship it is. As soon

as this is known, a chain is attached to the good end, and it is left hung up to a buoy, whilst the ship proceeds to pick up the cable towards the fault, cutting and testing it from time to time in order to see whether the fault has come on board. As soon as this proves to be the case, new cable, which has been stored in one of the cable tanks on board the ship, is spliced on to the end of the cable which is being picked up. This is then paid out over the bow sheave in the direction of the buoy. This operation completed, the end of the cable hung up is taken on board and the two ends spliced together, and the bight carefully lowered to the bottom.

Several types of grapnels are used, according to the varied conditions of the bottom, but perhaps the one most frequently used is the centipede grapnel. This grapnel is made in two sizes—the larger about 2 cwt. and the smaller 1¼ cwt.—and it has the advantage of being of strong construction and not easily broken on rough ground. It hooks the cable securely, and if a prong does get broken through hooking a rock, the damaged prong is easily replaced—see Fig. 3. The grapnels are regularly kept very clean, and painted grey, as a speck of tar on the grapnel occasionally affords the most important evidence, and, in fact, may be the only proof that an old cable has been touched.

In the lifting of an old cable which is in a very weak condition, it sometimes becomes necessary to hang it half way up on to a bight buoy, and then to hook the cable a second time between this buoy and the broken end, so that the cable may be lifted to the surface without putting the whole weight of it on one grapnel—Fig. 4. It is, however, more usual to utilise the Lucas cutting and holding grapnel, which is designed to hook the bight of a cable, to cut and drop one end, and to grip and raise the other end to the surface. It is dragged over the bottom with the folding arms in the position shown in the left-hand view in Fig. 5. When the cable has been hooked, the bight is raised until it becomes tight; the strain then breaks the bolts which keep the arms extended, and the tension on the wire ropes causes the arms to fold down on to the shank, consequently gripping the cable on one side and cutting off the other. The right-hand view in Fig. 5 shows the grapnel when the bolts have been broken, the folding arms gripping one end of the cable in the serpentine-shaped space between them and the shank, the knives having closed together and cut away the part of the cable not required. The builders of the Telconia have had considerable experience in the construction of cable-laying and repairing steamers, and amongst the vessels which they have built during recent years are the Colonia and Cambria, both for the Telegraph Construction and Maintenance Company, Limited.

THE ELECTRICAL DRIVING OF A LEAD WORKS.

ABOUT a year and a-half ago the firm of Foster, Blackett, and Wilson, which, during the fifty years it has been established at Hebburn-on-Tyne, has contributed very largely to the prominent position which Tyneside holds in lead manufacture, became convinced of the advantages of the electric drive, and decided to equip electrically the whole of its works, taking a supply of current from the Northern Counties Electric Supply Company. The result of the last year's running has, we understand, in every way justified the decision. The work of conversion was entrusted to Chas. Martin and Co., Newcastle-on-Tyne, the wiring to Warren, Beattie and Co., of Middlesbrough, and the manufacture of the complete equipment of motors, auto-starters, and controllers to the British Westinghouse Electric and Manufacturing Company, Limited.

The firm devotes itself entirely to the manufacture of lead products, and does not smelt its own lead. It obtains its chief supply of raw material in the form of pig lead from Spain, the ore having been melted on the spot. At one time these pigs used to contain from 20 oz. to 80 oz. of silver per ton, which was separated out by the Pattinson process at the works. Now-a-days, however, the silver is extracted in Spain; but this process is still very largely used for refining the lead where great purity is a necessity, as is the case with sheet lead for use in chemical works and for making white lead. Messrs. Foster, Blackett and Wilson are among the few firms which refine exclusively by this process, and they make a speciality of "chemical" lead.

The raw materials, *i.e.*, lead pigs, oak bark, &c, are brought to the works by water and hauled in trucks by a single-drum haulage at the top of an incline running from the company's private jetty on the Tyne. The haulage-way is some 200 yards long, and has an average gradient of 1 in 10 up the bank. Red lead, white lead, and refined lead are also conveyed by this path, and turntables are placed at intervals from which branch roads lead into the various departments of the works for sea shipment. The maximum load of each truck when full is 6½ tons, and the full load haulage speed is 7 miles per hour. The gear was formerly driven by a vertical double-acting steam engine, with its cylinder below the crank shaft. On conversion, the crank shaft of the engine was taken out and a gear wheel and countershaft put in, by means of which it is now driven by a 60 horse-power motor operated by a drum controller. One of the main objects in carrying out the conversion was to avoid delays, so that existing gear was used as much as possible. The capital outlay, therefore, was kept down, and is, we are informed, very low for this class of work. The whole of the conversion was carried out without a shut down or causing any serious hitch in the operation, the longest interval occurring in connection with the haulage gear, which was carried out during the Christmas holidays.

Fig. 1—THE LEAD MILL

In the separating house the lead pigs are refined and the pure lead run into a mould about 8ft. square, in which a mass of metal, weighing about eight tons, is formed. This metal slab is lifted by a jib crane and swung over to the bed of the lead mill. This crane was formerly operated by a two-cylinder double-acting steam engine, the crank shaft and cylinders of which were taken out, a countershaft and gear wheel put in, and the drive effected by a 10 horse-power motor, operated by a drum controller. The lead mill, which is shown in Fig. 1, has rolls about 20in. in diameter and 8ft. 3in. long, the bottom one being positively driven and the top one running loose, but giving pressure. A series of six live rolls, standing slightly above the bed of the mill on either side of the main rolls, facilitates the passing of the billets through the mill, and beyond this there are dead rolls for easing the work, the bed being 120ft. long. The fly-wheel, which was retained for equalising the load on the motor, weighs seven tons, and has a diameter of 19ft., in contrast to which the motor is almost lost sight of.

This mill was originally driven by a two-cylinder horizontal engine, of about 200 indicated horse-power and 4ft. 5in. stroke, working at 60 lb. steam pressure. Upon conversion the crank was replaced by a gear wheel, and the countershaft carrying the pinion engaging this wheel is now belt-driven by a 90 horse-power slip-ring motor. The original reversing gear, comprising two pinions keyed on to the fly-wheel shaft, one of which engaged directly on to a loose gear wheel on the roll shaft, the other gearing on to an idler, which in its turn engaged with another loose gear wheel on the roll shaft, has been retained. By means of a four-jaw double-headed clutch, sliding on a feather key on the roll shaft, either one of the loose gear wheels is engaged with the shaft, and these revolving in opposite directions reverse the motion of the mill. A pair of rolling cutters at each side of the bed is used for trimming the edges of the sheets when necessary, and also as a guillotine for cutting the sheets into length. Both of these are operated from the gearing of the mill. The largest sheets rolled are 8ft. wide by 45ft. long, and up to 1in. thick, while sheets as thin as $\frac{1}{14}$th of an inch can be rolled.

It has been found, we gather, that the installation of the electric drive has resulted in a much larger output of the mill, owing to the steadier drive. A three-ton jib crane is used for loading the finished lead from the mill bed, and this has been converted to electrical working, and equipped with a 10 horse-power motor for lifting, the motor and controller being mounted on a bracket swinging with the crane. The crane cannot make a complete turn, so collector rings are unnecessary, and, as in the above-mentioned crane, slewing is done by hand.

Adjacent to the lead mill are two similar pipe presses, one of which is shown in Fig. 2, each machine consisting of an hydraulic press which forces the solid lead out of a steel container through a die, a steel core being bedded in the container, the size of the core settling the inside diameter of the pipe. Pipes can be made varying from $\frac{1}{16}$in. to 9in. inside diameter, a maximum hydraulic pressure of 3½ tons per square inch being exerted on an 18in. diameter ram. The fly-wheel of the three-throw plunger pump, which was steam driven, was replaced by a 6ft. diameter pulley belt driven by a 30 horse-power slip-ring motor. A great improvement has been found in the class of pipe turned out, especially in the case of tinned lead pipes, owing to the even turning moment of the motor, in addition to which a quiet drive is now obtained.

At the other end of this house there is a group of machinery consisting of a lathe for general work, a set of flue paddles,

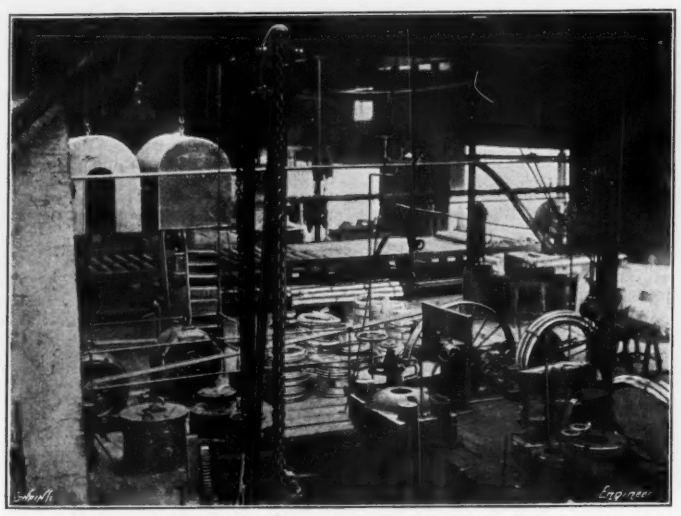


Fig. 2—THE PIPE PRESS SHOP

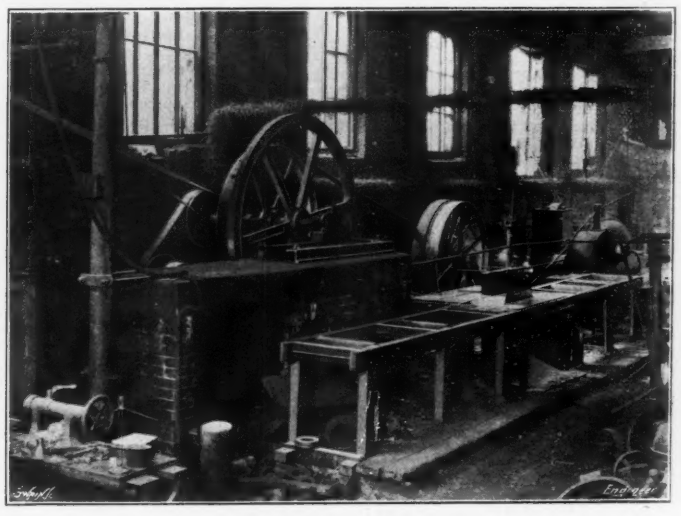


Fig. 3—ELECTRICALLY DRIVEN SAW AND FAN

a circular saw, and a cupola blast fan, shown in Fig. 3. The cupola is used for melting down to pigs all the lead residues and slags which are formed during the various processes of manufacture, and which cannot otherwise be reduced. Any lead dust escaping with the fumes from the cupola is caught by the water sprayed up by the flue paddles, and settles in a tank. This group was formerly driven by an old type horizontal single-acting steam engine, and on conversion the piston and connecting-rod were removed, the fly-wheel retained, and the machinery driven by a 20 horse-power motor.

This firm also makes white lead on a very large scale, and the department for the production of this material is one of the most interesting of its class in this country. Metallic lead is converted into white lead by the old Dutch process, and the white lead is then separated out by roller tubs consisting of two copper corrugated rollers and a perforated screen, the metallic or "blue" lead being used over again. The white lead is finely ground by four sets of three pairs of grinding stones in series. After leaving these stones and being washed by dollies it settles in settling tubs, and is finally dried and packed.

For loading and unloading the stacks five overhead electrically driven jib cranes are used, provided with switches for throwing the motors on and off the mains. The crane travel is obtained by means of an ingenious jockey pulley rope drive. Parts of the old gear have again been used, and the hoisting, slewing, and traversing are carried out by friction clutches from the ground. This is a great improvement on the old arrangement, in which nine cranes were used, driving through an endless rope drive by a 50 horse-power gas engine running on town gas. The convenience, economy, and simplicity of the electric drive has here been probably most strikingly demonstrated.

The two white lead grinding equipments were driven by two steam engines, one being of 120 brake horse-power, and the other an old beam engine with a 5ft. stroke and 20ft. fly-wheel running at twenty-six revolutions per minute. These are now replaced by 50 horse-power motors driving the existing shafting through a belt and a 10 to 1 gear reduction. From this shafting the grinding mills and hoists for lifting the lead from the ground to the roller tubs are operated. The greater portion of the white lead is sold in the form of white paint, and for the production of this two large Torrance mixing machines are used, driven by a 60 horse-power motor geared to the old shafting, which also works a 1-ton hoist, raising the dry white lead to the machine hoppers, an oil pump, and a dust extractor fan.

Fig. 4—MIXING HOUSE AND RED LEAD MILL

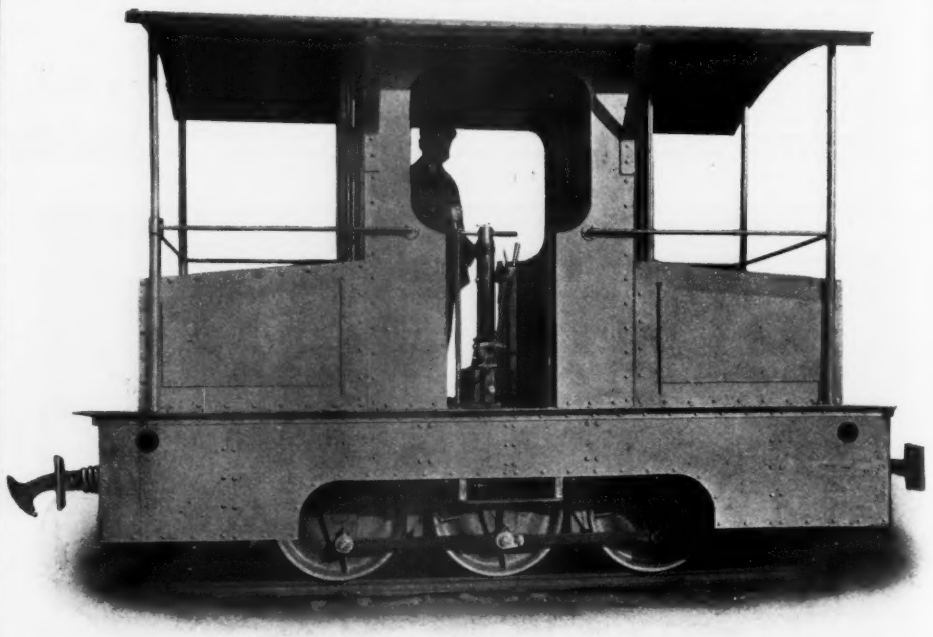
In the manufacture of red lead, metallic lead is heated and oxidised in large drossing ovens called "waste furnaces," and in the presence of free air is converted into litharge PbO. This is then put through grinding stones and a levigating plant, the lighter litharge being washed over into settling tanks, while the heavier metallic impurities sink, and are collected and sent back to the "waste furnaces." The litharge is taken from the settling tanks and placed in a second series of ovens, called "colouring furnaces," where it is again oxidised, taking up more oxygen and becoming red lead (Pb_2O_3). After cooling this is ground through another set of stones and finally taken out and dried. The whole of this grinding plant is driven by a 50 horse-power motor, geared to the original shafting, and on account of the great overloads which may occur, owing to improper use, a large-faced ammeter with a danger line indicating the overload point is placed in the front of the operator. Originally this plant was driven from the beam engine which drove one of the white-lead grinders.

Adjacent to this mill is a dust extractor fan, a mixing, and a sifting machine driven by a 10 horse-power motor, which is shown in Fig. 4, in the right-hand side of which can be seen the covered-in motor driving the red-lead mill. To avoid dust in the packing-rooms, both rooms contain a Sturtevant fan, about 3ft. diameter, running at 900 revolutions per minute and driven by a 5 horse-power motor.

Great care has been taken to protect the motors from dust, and in most cases loose sheet iron covers, which can be lifted by means of wire ropes passing over pulleys suspended from the cross beams, and which are balanced by counter weights, are fixed over the motors. Every precaution is taken to prevent lead poisoning, and it is for this purpose that dust extractors are used in all parts of the works in which there is a likelihood of there being any lead dust in the atmosphere.

PETROL LOCOMOTIVE FOR ASSAM

McEWAN, PRATT AND CO., LONDON, ENGINEERS



PETROL LOCOMOTIVE FOR ASSAM.

THE accompanying illustration shows a petrol locomotive built by Messrs. McEwan, Pratt and Co., of 23, Leadenhall-street, London, to the order of the Assam Oil Company for use in that company's oilfields in Assam. It is built to the requirements of the Indian State railways for metre gauge, has six wheels coupled, the wheel base being 5ft. 6in. It will be used principally for shunting purposes, in consequence of which it was absolutely essential that the whole structure should be of a massive design throughout.

The engine is of the four-cylinder type, and develops 50 brake horse-power at 900 revolutions. The valves are all mechanically operated, and the magneto is fitted with this firm's Murray attachment to facilitate ease in starting the engine. The latter drives through gearing and then by two chains running in oil baths on to one of the axles, arrangements being provided whereby these chains can always be kept at the proper tension. A multiple disc clutch is fitted, with springs to assist in easy starting, and the shock in so doing is taken by springs fitted in the driving wheel. It has two speeds in either direction of 4½ and 10 miles per hour. The locomotive is guaranteed to haul a gross load of 67 tons on the level at 10 miles per hour, or the same load up a gradient of 1 in 84 at 4½ miles per hour; this performance, however, has, we are informed, been considerably exceeded. The draw bar pull, when travelling at 4½ miles per hour up an incline of 1 in 20, was 1900 lb. The consumption of fuel was low. A trial of the engine on the test bench gave 3½ gallons of petrol per hour with the engines running at 900 revolutions per minute and developing 50 brake horse power. This gives .56 of a pint per brake horse-power per hour.

Fuel capacity is provided by two 50-gallon tanks, and four ballast tanks are fitted capable of holding, if necessary, about 1½ tons of ballast. The net weight of the locomotive is 7½ tons, but when fully loaded with ballast and fuel in running order, the weight is approximately 9 tons. Brakes are fitted on all four wheels. A large cooling surface has been provided in the radiators owing to the extremely hot climate prevailing in Assam at certain seasons of the year. The circulation is on the thermo-syphon principle.

A NEW ELECTRICAL INSTITUTION.

ON Friday last the inaugural meeting of a new society, called the Institution of Mining Electrical Engineers, was held at the Midland Hotel, Manchester. The first president is Mr. W. Maurice, and among the objects for which the institution has been formed are: (1) "To consider means for minimising the risks attending the application of electricity to the industry of mining, and to promote the adoption of approved methods and devices tending to increase safety; (2) to promote the general advancement of electrical science in its application to the industry of mining: to facilitate the exchange of information and ideas on this subject amongst the members of the Institution and otherwise, and generally to extend the experience, increase the efficiency and elevate the status of those engaged in such applications." There was a very fair number of gentlemen present, hailing chiefly from the northern counties, and after the formal business of election of officers, &c., had been disposed of, the President delivered an address. This was of a very comprehensive character, and much too long for us to publish *in extenso*. The president said that this association was not an offshoot nor was it a rival of any existing corporate body. On the other hand, it would seek to work in harmony with all whose objects were in any way related to its own. It was new in a wider sense than in merely forming the latest addition to the already large number of technical societies, for although it was intended that it should seek to obtain professional authority and distinction, it stood initially as the inspiration of a small body of hitherto unorganised electrical craftsmen. It was, he said, the first indication of a class consciousness in a large and responsible group of electrical engineers and artisans who had acquired practical experience in mines, and were desirous of extending that experience and of rendering it more generally useful to each other and to the community. It was an indication of the trend of events which was not unworthy of the attention of mine owners that a substantial number of mine workers, occupying for the most part responsible but minor positions, were taking upon themselves to devote some of their limited leisure to the elucidation and publication of matter concerning the practical problems connected with their daily work, in order that the risks to life and property associated with the use of electricity in coal and metalliferous mines might be reduced to the utmost possible extent.

The members dined together in the evening, Mr. Maurice, the president, being in the chair. The toast of the "Institution of Mining Electrical Engineers" was proposed by Dr. Thornton, of Newcastle, and was responded to by the president. Mr. G. H. Winstanley, Lecturer in Mining at the Manchester University, proposed "The Mining Industry," which was replied to by Messrs. Holliday and W. Ritson. The chairman, in the course of a few remarks, stated that the new Institution had the full support of the National Association of Colliery Managers.

On Saturday the members paid a visit to the works of the British Westinghouse Manufacturing Company at Trafford Park, where they were entertained at luncheon.

THE NEW WARSHIPS.

THE contracts for the four new contingent warships were awarded last Saturday by the Admiralty. These vessels come under the Navy Estimates of the current financial year, and their construction was authorised to be commenced on April 1st, 1910, if the progress of foreign naval additions were such as to justify it. Three of the new vessels, we hear, are to be similar to the Orion, laid down a few weeks ago at Portsmouth, and a forecast of which we published in our issue of November 26th last. These battleships will be built by Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne; William Beardmore and Co., Limited, Dalmuir; and the Thames Ironworks and Shipbuilding Company, London (conditionally). The fourth vessel is to be a cruiser of the Lion type, and will be built and turbined by Vickers, Sons and Maxim. The propelling machinery of the three battleships is likewise to be of the turbine type, that required for the Newcastle ship being supplied by Hawthorn, Leslie and Co., Limited; while the Dalmuir firm will supply its own turbines, and those for the Thames Ironworks will be constructed by the Wallsend Slipway and Engineering Company, Limited, Newcastle-on-Tyne.

THE UNIVERSITY OF SHEFFIELD.—The Council, at its last meeting, appointed Mr. A. B. Coward, B. Eng., to the post of demonstrator in the Department of Engineering. At the same meeting the Pro-chancellor (Mr. George Franklin) and the Vice-chancellor (Sir Charles Eliot) were appointed representatives of the University on the Executive Committee of the Modern University Congress.

THE ELECTRICAL ENGINEERS (LONDON DIVISION).—The annual dinner of the Electrical Engineers (London Division) took place on Saturday last at the Café Monico. Col. R. E. B. Crompton, C.B., the Commanding Officer, was in the chair, and the dinner was attended by over 200 officers, non-commissioned officers, and men with their guests. After the usual loyal toasts, the chairman, in proposing "The Imperial Forces," referred to the needs of national defence, and the increasing enthusiasm in the country for the Territorial Force. Brig.-Gen. F. Rainsford Hanney, R.E., who replied, referred to the past work of the Corps and to the varied possibilities of the future. Col. Crompton then presented the Hopkinson and the Officers' Cups, which are competed for annually for technical work and drill respectively. Both cups were won this year by "A" Company. The technical competition was this year of an unusually severe character. The instructional plant at headquarters, consisting of two oil engines and a steam engine, with three projectors, was dismantled by an imaginary enemy, who had introduced a number of hidden but very effective hindrances to the running of the engines. The working party, consisting of an officer and thirty non-commissioned officers and men, discovered and rectified the various defects and had the three lights working within three hours of starting work on the "wrecked" plant. The toast of "Science and Engineering" was proposed by Major Leaf and replied to by Professor Kapp and Captain Dumble, R.E., formerly adjutant of the Corps.

RAILWAY MATTERS.

FIVE accumulator cars have been in operation on the Belgium State Railways since 1899, between Antwerp and Lierre, distant apart about 10 miles. Each car weighs about 40 tons and carries sixty-six people. The Government will buy more cars to operate between Antwerp and Malines.

THE first car of a service on which a farthing fare will be charged was run on Thursday, December 16th, over the new track of the Metropolitan Electric Tramways Company from Golders Green Tube Station to Tally Ho Corner, North Finchley. The journey of 3¼ miles will be covered in about twenty minutes.

WORK on the Jungfrau Railway is steadily advancing at the rate of between three and four metres a day. The workmen, who number 130, are at present engaged in boring the tunnel between the Eismeer Station, 10,345 ft., and the Jungfrau Joch, 11,090ft. above sea-level. At the present rate of progress the line should be completed towards the end of 1911.

BRIQUETTED Pocahontas coal, in eggette and brick shapes, has been tested on a freight locomotive in comparison with run-of-mine coal, and found to give 10 to 15 per cent. greater evaporation. The tests were made for the U.S. Geological Survey by Messrs. W. T. Ray and Henry Kreisinger, who report it is easier to keep up steam with briquettes than coal.

THE annual report of the South Australian Railways Commissioner for 1908–9 states that the permanent survey for the proposed 5ft. 3in. gauge railway line from Gawler to Angaston, a distance of 24 miles, has been completed, and the work of construction is to be put in hand at an early date. It is expected that the line will be completed by February, 1911.

IN Italy considerable progress is being made in connection with the electrification of railways. The Government have decided to electrify eleven sections on the State Railways, aggregating 337 miles of track, but on the 3-phase system. Thus the battle of the phases is still undecided. The decision of the Italian State Railways to use 3-phases, while in Germany, Austria, England, Sweden, and America the single-phase system is preferred, is highly interesting.

THE *Mexican Herald* of 25th November states that the interests which propose to build the Guadalajara-Chamela Railway have formed a syndicate, and it is planned to begin construction work early next year. The line is to run from the Pacific Port of Chamela to La Vega, 43 miles from Guadalajara, where it is to be connected with the Ameca Line of the National Railways; it will be 325 kiloms. (about 200 miles) long, with a branch line 25 kiloms. (about 16 miles) in length to Ayutla.

THE Long Island Railway Company of America announces that by 31st December the electrification of 40 miles of track will have been completed, and more than 140 miles of road will be ready for the operation of electric cars. On 1st June, 1910, the lines will be in full operation, and by that time work will be well advanced on the electrification and double-tracking of the entire North Shore division of the road from Winfield Junction to Flushing, Whitestone, Malba, and Whitestone Landing, and from Whitestone Junction to Port Washington.

EXPERIMENTS made on the Valtellina three-phase railway, described in *l'Industrie Electrique*, showed the general result that the effect of stray currents from the railway on the adjoining telegraph lines was quite negligible; electrostatic induction was also of small moment, but the electromagnetic perturbations were very serious. It was found necessary, when the line commenced electrical working, to provide metallic circuits for the telegraphs in the neighbourhood of the railway, with translators at the terminal points, but this was both inconvenient and expensive, and required skilled attendance to keep the translators in good working order. Nevertheless, there seemed to be no better way out of the difficulty, short of compelling the railways to use continuous current.

ACCORDING to an American contemporary, 150 locomotives of the Lehigh Valley Railway are being fitted with a new fuel-saving device. On all the locomotives the air-brake pumps are operated by steam, and it has been the practice to conduct the exhaust steam from the pumps to the smoke-box, to which the stack is attached, and then to release it, causing a draught. Considerable work is done by the brake pumps when the locomotive is at a standstill, thus causing a needless loss of fuel. By the new arrangement the exhaust steam is carried outside instead of inside the smoke-stack. Tests made by the above-named railway show that the company is saving about 1000 lb. of coal per locomotive on the descent of the grade from Glen Summit to Penn Haven Junction, Penn., a distance of twenty-six miles.

THE chairman of the Light Railways and Tramways Committee drove the first car over the new length of tramway extending from Golders Green, Hendon, to Tally Ho Corner, Finchley, on Thursday afternoon, December 16th, which section is now opened to public traffic. The length referred to forms part of a line which will eventually link up Cricklewood, Willesden, Harlesden and Acton, in the county of Middlesex. The terminus in the latter district is within about eighty yards of the London United System, which continues through Acton, Ealing, Hanwell, Brentford, Isleworth and Twickenham to Hampton Court, Kingston, Malden, Wimbledon, &c., so that when the section belonging to the Middlesex County Council (referred to above) is linked up at Cricklewood it will be possible to board a car at Barnet (Herts), and travel some 35 miles without a break of more than 80 yards in the total journey.

ACCORDING to the *Electrician* the Prussian Ministry of Railways has decided that all sleeping cars must be fitted with electric light before October 1st, 1910. This decision has been come to owing to the fact that this form of lighting allows greater safety to the passengers than does gas. The Ministry of Railways, it appears, was not at first at all favourable to the idea of equipping these cars with electric light, in spite of the fact that dangers, arising from using gas for this purpose, had been pointed out by a number of railway authorities. This idea on the part of the Ministry seems to be partly due to the fact that only in Denmark and Sweden was electric lighting universally used, but it is now pointed out that the Orleans railway in France has recently equipped 1100 of its cars with the Stone system of electric lighting, while 900 cars on the same railway are being fitted with the Aiche system. This system is also employed in 1800 cars on the Swiss Railways, and is being fitted in 200 cars at the present time.

THE opening of traffic for the Boston Elevated Railway Company's 2.5-mile extension to Forest Hills on November 22nd added another link to the chain of rapid-transit routes radiating from the business centre of Boston to the nearer suburbs. It makes possible a saving of 18 minutes per day to the passenger who travels between his home in the West Roxbury wards of the city and the mercantile district. The value of the time saved will probably tend to deflect traffic from the New Haven suburban steam lines at the south of Boston, on account of the network of distributing stations and tracks which the Boston elevated system maintains in the business centre of the New England capital. By establishing but a single stop between Dudley-street and Forest Hills, the company maintains a high average speed to the suburban centre at the latter point, and transfer tickets to and from surface cars serving the outer suburbs complete the flexibility of the system. The Forest Hills extension and the Cambridge subway now being built are thus, says an American contemporary, simply and clearly parts of a logical scheme of transportation which is benefiting the entire metropolitan district.

NOTES AND MEMORANDA.

COMMENTING on the growth of the motor car in France, a recently issued consular report states that on February 2nd, 1908, an observer stationed at the entrance to the Avenue des Champs Elysées counted between three and seven o'clock 2953 automobiles passing that spot, and on the 8th of the same month 3430.

A BELGIAN law of August 20th relating to the use of white lead allows the importation, sale, transportation and use in Belgium of painters' white lead only in form of paste and oil, and prohibits the dry scraping or pumicing of any surface coated with white lead. The importation of white lead in powder, lump, or cake form is allowed for other purposes than for the manufacture of paint.

GREAT Britain practically monopolises Germany's imports of steam-driven heavy tractors and rollers, which, during the first three-quarters of the current year, reached a value of £20,500, compared with £15,650 in 1908. With the exception of some 280 cwt., the collective tonnage is credited to British makers, whose shipments to Germany exceeded, by over 3600 cwt., Germany's entire exports in this class of goods.

ON Thursday, December 16th, Dr. W. H. Eccles and Mr. A. J. Makower read a paper before the Institution of Electrical Engineers on "The Efficiency of Short Spark Methods of Generating Electrical Oscillations." The authors described apparatus which they have used for measuring the efficiency of the form of discharger employed by von Lepel. Particulars of their tests were given. The highest overall efficiency recorded was 14·4 per cent.

IT is known that the wave of open-circuit p.d. between the lines of a three-phase generator contains no harmonic which is a multiple of three, whatever the shape of the e.m.f. wave in each phase. When a pronounced third harmonic exists in each phase then the windings ought to be connected in star, and not in mesh. In illustration of these points the author of an article in the *Electrical World* gives the results of tests made on a three-phase alternator whose flux wave had a prominent third harmonic. He explains how the oscillograms verify the theory.

IN the course of the discussion on Messrs. Marchant and Watson's paper on "Long-distance Transmission on Overhead Lines" some useful hints were given as regards insulators. Professor Schwatz advocated long spans in order to minimise the number of insulators used. He said that they should be designed to work in compression. As regards the point where to use pin or suspension-type insulators, the limit came when the stress between the line wire and the pin-head became high. It was necessary to have a thick piece of porcelain between the line and pin.

AT a recent meeting of students of the Northern Architectural Association Mr. J. G. Smith read a paper on "Portland Cement Manufacture and Testing," giving first a historical sketch of the Portland cement industry, and then describing and illustrating the marked improvement evidenced during recent years in respect of fine grinding. Reference was made to the expansion test, more generally recognised and welcomed by cement manufacturers as a means of ensuring more adequate consideration of cement exhibiting progressive increase of strength with age as distinguished from quick-setting cement, which gives high results on a seven days' tensile test and thereafter deteriorates. The author illustrated his paper by practical demonstrations of cement sifting, and gave his audience the opportunity of witnessing tests of briquettes for tensile strength.

A PATENT issued on November 30th, 1909, on an application filed on December 14th, 1904, by Reginald A. Fessenden, relates to a method for locating the position of ships by means of wireless telegraphy. According to the arrangement proposed, signals are sent out at regular intervals from two or more wireless telegraph stations situated at fixed points, each vessel locating its own position by comparing the strengths of the signals received. Each land station sends out a distinctive signal so that it may be recognised immediately by any vessel. Moreover, the strength of the signal from each land station is varied so as to form a succession of signals of gradually varying intensity so that each signal shall produce the same intensity at a point 20 miles farther from the station than the signal immediately preceding it. Thus the operator on each vessel first identifies the station from which each signal is being sent, estimates the relative distances from the vessel to each land station, and thereby determines the position of the vessel on the sea.

HANDLING coal and ashes by hand in the 1500 horse-power plant of a paper mill is shown to be pretty expensive in a paper read by Mr. David Gaehr before the Ohio Society of Mechanical, Electrical, and Steam Engineers. The coal is delivered on a covered trestle adjoining the boiler-house and dumped to the ground, whence it is wheeled to the boilers and fired by hand. Three firemen, three coal passers per 12-hour shift, and four shovellers are employed, and the labour cost of handling the coal and ashes amounts to about 1s. 7d. per ton. If half the wages of the head fireman, who merely supervises the fire-room, and one-third the wages of the chief engineer are also charged to this item, the cost is raised to 1s. 10d. a ton. In addition to this heavy expense the ashes must be shovelled into a wagon and hauled to a more remote place on the premises. The firemen and coal passers are worked so hard as to force them to take advantage of every opportunity to exchange their places for better ones, thus making a permanent organisation in the boiler-room a practical impossibility.

AN engineering correspondent in Japan, writing in *Ferro-Concrete*, states that he lately had an interview with Professor Omori and Professor Nakamura, the seismologists of Japan, who are sent regularly by the Japanese Government to inspect the results of any important earthquake which may take place, so as to advise the Government as to the best architecture for resisting the effect of earthquakes in Japan. They went to Messina, and as the result of the inspection they are both very much in favour of ferro-concrete as long as the work is thoroughly carried out. At Messina Professor Nakamura saw the house of Mr. Hennebique's agent, which had been quite undisturbed by the earthquake; he also saw some factories of which the frame was ferro-concrete and the walls of brick, the latter having fallen out, leaving the concrete frame intact. Professor Omori also was very interested in what he saw at Messina, especially in the case of two large reservoirs, one of brick and the other of concrete, the former being completely destroyed, while the latter was not in any way damaged.

THE President of the Ohio Society of Mechanical, Electrical, and Steam Engineers, Mr. F. W. Ballard, in the course of a paper on power costs for factories, gave calculations showing that the steam consumption of steam pumps is often at least five times that required by large central engines driving generators for supplying energy to motors for doing the same work, and in extreme cases, with long lines of steam pipe and intermittent service, the steam consumption has been found to be ten times what would have been required by central units for the same service. In the discussion which followed the reading of the paper Professor W. T. Magruder reported the results of an investigation which showed that the cost of operating a certain boiler plant for steam heating alone, in the winter-time, was nearly equal to the cost of running the plant for both the motor service and the heating service combined. In speaking of group drives, he cited a case where 800 horse-power was required to run the shafting during the noon hour, while only 1000 horse-power was needed to operate the shop during working hours. With mechanical transmission the losses may be from 40 to 50 per cent., while with electrical transmission the losses may be reduced to 15 per cent.

MISCELLANEA.

ACCORDING to the *Electrical Engineer*, the Prussian authorities are seriously studying the usefulness of wave telegraphy in fogs, and have established two small experimental stations on the Muggelsee, and very satisfactory results as regards penetration, and also as regards the determination of the direction from which the signal received has come, are said to have been already obtained.

WE hear that considerable interest has been created in the German chemical world by the decision to form an Imperial Chemical Institute. This institution is to undertake for the chemical industry similar functions to those which the Imperial Physical Institute performs for engineering. The undertaking is being subsidised by the State, and it is expected that the annual maintenance will cost about £10,000.

IT is reported in the *Times* that some interesting experiments in the application of electricity to agricultural purposes have just been made at Mitry-Claye, in the presence of representatives of the Minister of Agriculture, by M. Fillet. Electric motors are used to work a drum which rolls and unrolls a steel cable, to the end of which is attached a large plough. The electrical energy is obtained from a small central station on a neighbouring farm, and is conveyed to the apparatus by copper wires carried on movable posts.

THE Blackwell's Island Bridge controversy has apparently been settled by the announcement of the comptroller of New York City that he would make the final payments for the structure. This action is based on the advice of the Corporation Counsel, who holds that the city is equally responsible with the contractor for the failure of the structure to meet the full requirements of the specifications. The approval of the contractor's plans by the city's legal representatives is held to relieve the contractor from full responsibility for his part of the designs of the bridge.

ACCORDING to a contemporary, a new water-supply system has been completed at Taipeh, Formosa, the water being taken from the river Shinten through 36in. reinforced concrete pipes. The new works comprise two circular reservoirs 170ft. in diameter, and one measuring 180ft. by 90ft. All are 15ft. deep. There are six filter beds, each 100ft. by 125ft. A new concrete pumping station has been erected, and three engines each of 100 horse-power and three of 50 horse-power have been installed. The capacity of the new works is about 5,600,000 gallons, and the daily consumption is about 2,250,000 gallons.

IT is reported that the Liverpool Port Authority has decided to proceed at the earliest possible moment with the erection of wireless telegraphic stations on all the lightships and lighthouses on the shore margin of Liverpool Bay, with a centre intercommunication station on the roof of the new dock offices. The instruments will operate over a radius of 25 miles, so that each station will always be in communication with one station or the other. The stations will be quite separate and distinct from that which the Marconi Company has at Waterloo, but they are to work in co-operation with that station. The cost of the installation is estimated at £100,000.

THE following information is from the report by H.M. Commercial Attaché at Peking (Mr. W. P. Ker) on the foreign trade of China in 1908, which will shortly be issued:—The Canton waterworks, built at a cost of £300,000, with British machinery set up by a British engineer, were opened in August, 1908, and are run under purely Chinese management. Waterworks supplying the native town at Hankow were approaching completion, under a British engineer, in the spring of 1909. A waterworks company was formed in Swatow in 1908 and the shares eagerly taken up, but, at the time of writing the report, operations had not started. At various other places, such as Chinkiang, Chungking and Chinan Fu, waterworks projects have been mooted, but have failed for want of funds. The next few years are likely to see waterworks started in many of the larger cities.

AT a meeting of the Newcastle and Gateshead Chamber of Commerce recently Mr. Shaw, the secretary, reported that he had received a communication from the Postmaster-General stating that the underground telegraph line between Glasgow and Edinburgh had been completed with the exception of a short section within the city of Edinburgh. The line running southward from Newcastle had reached Stockton; the line to the west had reached Penzance, and the extensions from Birmingham and Bristol had reachd Worcester and Berkeley. A pipe is to be laid southwards from Stockton to Leeds, where the underground line from London by way of Warrington and Manchester ends. The line to the west will be completed to Porthcwrnow, where cables are landed, and from Berkeley a pipe will be laid northwards to Gloucester, another step towards the connection of Birmingham with Bristol. A second underground line between London and Birmingham, which has been in progress for some time, will be completed, and a pipe will be laid from Chatham to Canterbury for the extension of the underground line now running from London to Chatham, the intention being to provide underground connections with the landing places of the principal submarine cables to the Continent.

IN a paper read before the Institution of Electrical Engineers on "Notes on Methods and Practice in the German Electrical Industry," by Messrs. L. J. Lepine and A. R. Stelling, it is stated that almost all German firms insist upon the acceptance of their own specifications, and will rarely if ever depart from these. Under this system makers stand or fall by their own designs and productions; they do not suffer the annoyance of petty alterations, and the experience of their experts in each branch enables them to supply an adequate article without having to submit to outside individual ideas. However strict a specification may be, bad workmanship will destroy its object. As regards dynamo-electric machinery, an 80 deg. Fah. rise after a six hours' run on full load seems to be the standard figure. Motors are rated to stand 25 per cent. overload for one hour, and 40 per cent. for three minutes, these overloads varying according to the size of the machines, and not being so high as those offered by some of the English makers. The designers differentiate between slow, high, and extra high-speed machines, the latter being classed as "turbo-machinery," and are treated in a separate department. The line of demarcation between slow and high speeds is 20 m./sec. peripheral speed.

A REMARKABLE paper on "Quantitative Measurements in Connection with Radio-Telegraphy" was read before the Institution of Electrical Engineers by Professor J. A. Flemming on Thursday, December 16th. The Professor remarked that it must always be borne in mind that in radio-telegraphic stations the standby costs were so vastly greater than the cost of power actually used in signalling that even a large improvement in the efficiency of transmission would not greatly reduce the total costs. Nevertheless, he shows that there is really room for improvement in this direction. In his efficiency chart for N.C.L. radio-telegraphic plant, with 5 mm. spark gap, he shows the rotary input at 2620 watts. The rotary losses amount to 1139 watts, while the rotary output is 1481 watts. At the next step we find transmission losses put down at 71 watts, and choking coil losses at 610 watts, leaving a transformer input of 800 watts. Of these 800 watts 302 are accounted for by transformer resistance losses, and 53 by transformer iron losses, leaving 445 watts delivered to condenser. There is then a loss of 351 watts in primary oscillation circuit, leaving only 94 watts for delivery to antenna, and antenna resistance accounts for another 16 watts, so that ultimately of the 2620 watts only 78 are used in final radiation work.

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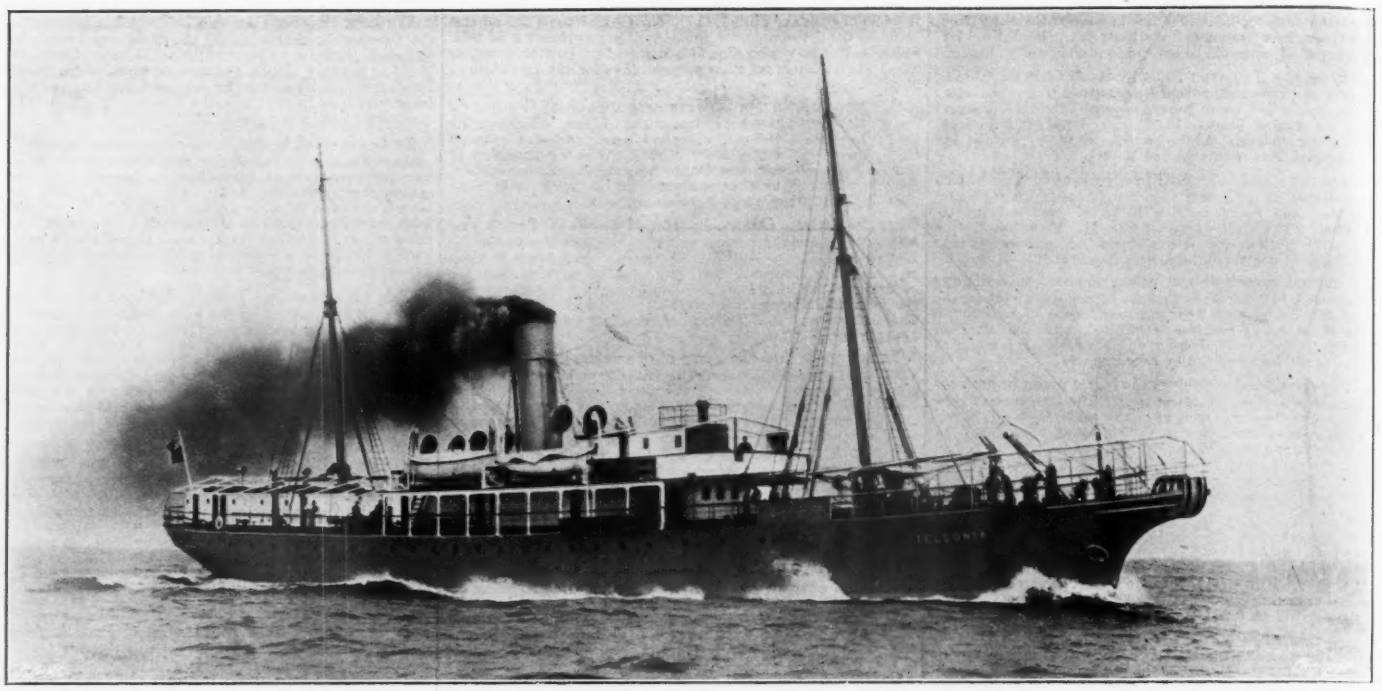
(For description see page 660)



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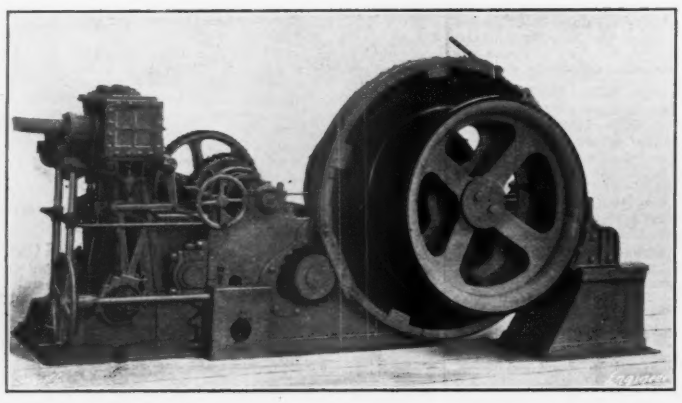
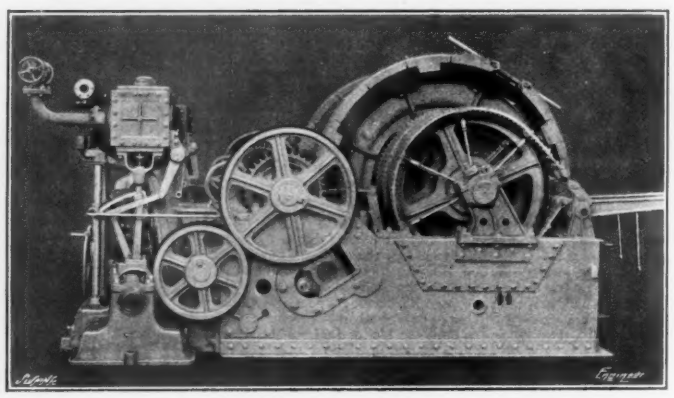
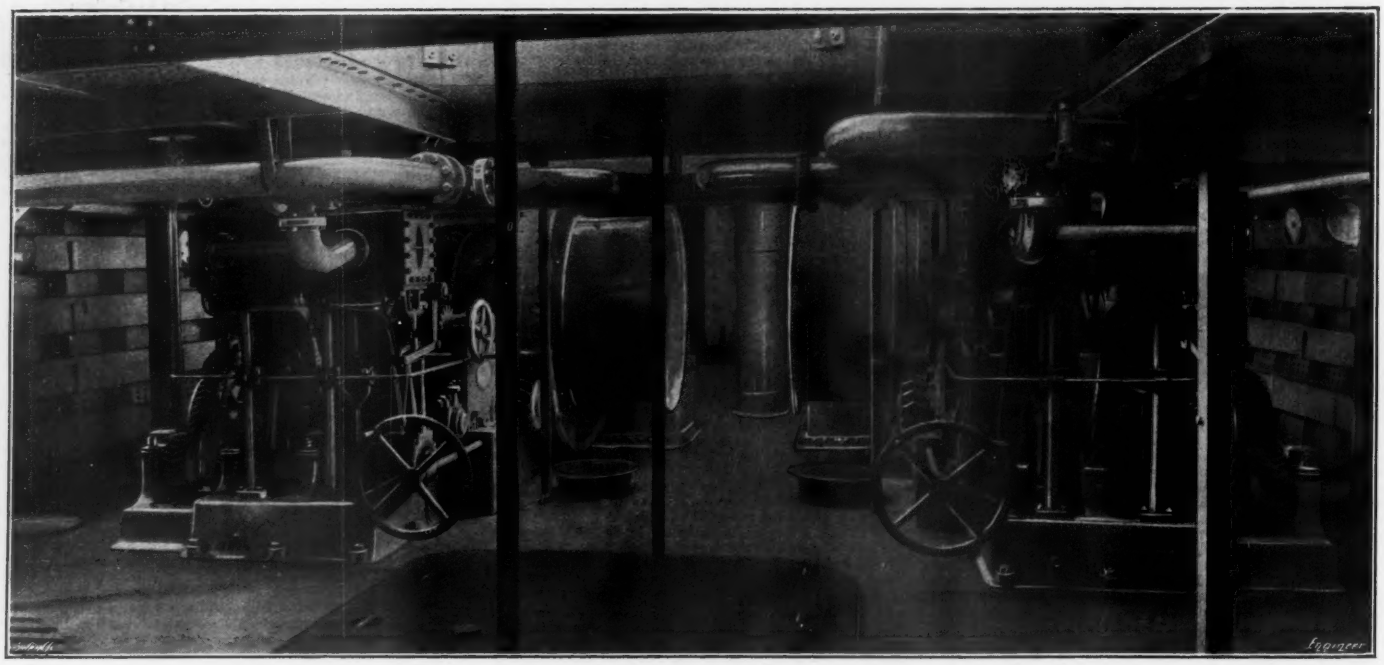




INBOARD AND OUTBOARD SIDES OF ONE OF THE PICKING-UP MACHINES



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CONTENTS.

THE ENGINEER, 24th December, 1909. PAGE

THE ENGLISH UNIVERSITIES AND ENGINEERS 653
LOCOMOTIVE PROPORTIONS AND POWER 654
ARMOURED CONCRETE TRUSSES 655
THE ROYAL COMMISSION ON CANALS AND WATERWAYS. No. XVI. (Ill.) 656
INSTITUTION OF MECHANICAL ENGINEERS. (Illustrated.) 657
MARCONI WIRELESS TELEGRAPHY. No. II. (Illustrated.) 658
A NEW CABLE SHIP. (Illustrated.) 660
THE ELECTRICAL DRIVING OF A LEAD WORKS. (Illustrated.) 661
PETROL LOCOMOTIVE FOR ASSAM. (Illustrated.) 662
A NEW ELECTRICAL INSTITUTION 662
THE NEW WARSHIPS 662
RAILWAY MATTERS 663
NOTES AND MEMORANDA 663
MISCELLANEA 663
LEADING ARTICLES—Engineering and Industrial Finance 665
Railway Fuel—Engineering, Science, and Business 666
A NEW FORMULA FOR THE TOTAL HEAT OF STEAM 667
LITERATURE 667
NEW FRENCH LOCOMOTIVES. (Illustrated.) 669
NEW CANTILEVER CRANES AT THE WALLSEND SHIPYARD. (Illustrated.) 669
THE KIEL DOCKYARD SCANDAL 669
POWER TESTS OF MACHINE TOOLS. (Illustrated.) 670
BUENOS AIRES EXHIBITION, 1910 670
MILD STEEL TUBES IN COMPRESSION AND UNDER COMBINED STRESS. (Ill.) 671
LETTERS TO THE EDITOR 674
THE INSTITUTION OF CIVIL ENGINEERS 674
SHIPBUILDING NOTES 674
THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS 674
NOTES FROM LANCASHIRE 675
THE SHEFFIELD DISTRICT 675
NORTH OF ENGLAND 675
NOTES FROM SCOTLAND 676
WALES AND ADJOINING COUNTIES 676
AMERICAN NOTES 676
PERSONAL AND BUSINESS ANNOUNCEMENTS 676
NOTES FROM GERMANY, FRANCE, BELGIUM, &c. 677
BRITISH PATENT SPECIFICATIONS. (Illustrated.) 677
SELECTED AMERICAN SPECIFICATIONS. (Illustrated.) 678

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REPLIES.

MASTA.—None of our colleges give special attention to railway engineering but all teach the general principles. Perhaps the Central Institution South Kensington, would be the best. A training in railway engineering works is absolutely essential.

DEATHS.

On the 10th December, at Forest Side, The Drive, Loughton, Essex, Mr. FRANK L. ROWE, for many years the esteemed manager of the Edwards Air Pump Syndicate, Limited.

On Saturday, 27th November, 1909, at Tientsin, North China, in the 55th year of his age, AUGUSTUS WILLIAM HARVEY BELLINGHAM, M. Inst. C.E., Engineer-in-Chief to the British Municipal Councils, Tientsin.

THE ENGINEER.

DECEMBER 24, 1909.

Engineering and Industrial Finance.

THE engineering business in Great Britain has during the last thirty years undergone a great change. Up to the eighties the engineering concerns of this country held supremacy among those of the world, and British engineers and machinery were to be found in all parts where such undertakings as waterworks, gasworks, tramways and similar ventures were being carried out. The leading position is being lost in all classes of engineering and industrial work. In the production of cast iron and steel this country is third on the list, and likely to go lower; and the British machinery maker has lost many of his former markets, and finds his present position in the home and colonial markets seriously threatened by the competition from America, Germany, and other countries.

It has been frequently assumed that this great change has been mainly due to the lack of technical education among managers and workmen, absence of commercial enterprise, and the action of hostile tariffs. This may be to a certain extent true, but of late years there has been a great increase in educational facilities, and many of our leading firms can show works equipment and enterprise equal to anything found abroad; there are, however, other factors which are not so frequently recognised. The increase in the use of machine tools and the decrease in the manual skill necessary to carry out various operations have allowed those countries not previously noted for the number or excellence of their mechanical operatives to compete successfully in the engineering world. One of the most important factors is that several nations have recognised that financial organisation, or the direct co-operation between the financial and industrial communities, can be made into a powerful weapon in the fight for the markets of the world. At one time a manufacturer, having obtained a concession for some waterworks or similar undertaking in a foreign country, could rely upon a considerable amount of financial support from his banker, these institutions being then largely interested in local ventures. Of late years a great alteration has taken place, the local banks have been absorbed by the big London banks, the bank owner with his interests has been lost among a board of twenty or thirty directors, banks have ceased to be directly interested in enterprise, and bankers in general, in their anxiety to accommodate all comers, have in many ways neglected the requirements of the home manufacturer for those of his direct competitors in other countries. There are many political economists and others, who, confining their vision to a limited horizon, consider the financial neglect of home industries and the large export of capital that has taken place to be a subject of congratulation. In a matter of this kind reliance must not be placed alone on academic theory, and many of those who have watched the rise of industry and enterprise in the chief competitors of the country state unhesitatingly that it is largely due to the action of financiers in co-operation with industrial interests, action involving frequently temporary loss of profit, to the ultimate advantage of themselves and the countries to which they belong. Large contracts for the supply of war material, battleships, the making of railways or tramways, and the building and operation of waterworks or power stations are not now-a-days decided solely on the cash price and the quality of work or designs submitted by the competing tenderers, though there has been a general levelling up in these two latter items, owing to the spread of education and the information given by the technical and daily Press. Competition for these contracts is frequently decided by a sort of financial artillery contest, technical details and prices being fixed after one party has become master of the situation. It has been the complaint of the manufacturer and contractor in this country that they have had to engage in many industrial struggles almost devoid of financial artillery, and to such an extent has this been the case, that many otherwise promising markets, in which British enterprise could easily compete on a basis of price and quality, have been abandoned as almost hopeless, this being especially the case in dealing with the Continent. Let us take a hypothetical case of a kind that has occurred frequently in connection with municipal and other large undertakings abroad, though something of the same kind has at times occurred at home.

Several firms from different countries enter into competition for an important work, among them being Brown, Jones, and Co., and a German Aktiengesellschaft. After a preliminary investigation by the technical staff, the firms are questioned regarding their financial strength. The English firm's representative states that his company's capital is £200,000, with directors Messrs. Brown and Jones, and their English bankers graciously allow a reference to a local correspondent, but take no further interest. The German firm may have a similar capital, but be backed by one or two of the large German banks with capitals of several millions sterling, and actively assisted by a bank on the spot in connection with them. These financial organisations use every effort on behalf of their customers, and in cases of this kind British firms have repeatedly lost contracts, despite lower prices and superior technical offers. Very often contracts of this kind lead almost to a monopoly in the district for the successful tenderer. It is not unusual after continental concerns have obtained large contracts or concessions, due to financial assistance, to find them coming to the London money market, after taking up prior securities themselves, and obtaining assistance from financiers and the public, though the competing English firm has been flatly refused any financial assistance other than that which may be backed by the mortgage of any buildings, machinery or securities uncovered by debentures. Firms having a call on a hundred thousand pounds or more at short notice are in a position to capture markets in detail, and for this reason a number of enterprises originally started by English firms have been taken over by continental interests, and not only have many Englishmen been replaced by foreigners, but large periodical contracts have been lost to the country. Consular reports from all parts of the world tend to show that the increase of trade of Germany and other continental nations has been largely due to the support given by financial institutions, the absence of such support to British undertakings being frequently noted. Financial support need not mean long credit or wild speculation, but the fact that the support is there when wanted is of the greatest influence. One of the few cases of late years where financiers have given support to British industry abroad has been that of the Argentine, and as a result South America is one of the best foreign markets for the rolling stock makers and general engineering works.

The activities of the Deutsche, Dresdner, and other German banks, which are almost national institutions, have been a great support to German trade and influence in Turkey, China, Spain, South Africa, and South America, and recent events show that the American Government is encouraging enterprise in China through New York bankers. Unfortunately there are in this country no institutions which assist manufacturers to compete with the powerfully backed foreign concerns. Industrial investment trusts have not always been a success, and industrial enterprise has to depend largely on the independent financier or company promoter. There is no doubt that some of the Continental and American banks have gone too far in their support of industry and speculative ventures, but that does not mean that nothing should be done over here. The great joint stock banks, from the very nature of their business, are unable to come to the assistance of commercial ventures to any great degree, but to the minds of many business men

comes the thought that if this country is to retain its position some alteration must take place in the existing system of unorganised industrial finance, and weapons must be put into the hands of engineers and traders to enable them to resist the attacks which are taking place from all directions.

Railway Fuel.

It is curious that the quality and peculiarities of the coal used in locomotives is rarely made the subject of papers or discussions. It would seem that coal is regarded by locomotive superintendents as just coal, and nothing more—a substance about which it is not worth while to exchange opinions or try to obtain information. We cannot call to mind the existence of any treatise or book which deals specially with locomotive coal and its influence on the performance of the engines, and the cost of working traffic, and only one paper—see THE ENGINEER, October 18th, 1907; and while this is peculiarly true of Great Britain, it is also true of Europe. In the United States some information has been occasionally collected by circulars sent to the master mechanics of leading railroads, but the results amounted to very little. It is with the more pleasure that we announce the establishment of an International Fuel Association, with its headquarters in Chicago. The First Annual Convention was held on the 21st, 22nd, and 23rd of June last, and we have just received a copy of the "Proceedings," which are full of interest.

The membership in June was only 120, but it is probably twice that now. It includes men from the executive, operating, accounting, purchasing and maintenance departments. According to the opening address of Mr. Eugene McAuliffe, who is "General Fuel Agent" for the Rock Island and San Francisco lines, the Association has grown faster than any railroad organisation that ever sprang into being in the United States, or possibly in the world. The importance of the questions with which it will deal may be gathered from figures going to show that the value of the locomotive coal used in the United States represents about 190,000,000 of dollars, or say, £38,000,000. To this must be added about 90,000,000 of dollars, or £18,000,000, to cover the actual expense of conveying the coal to the railways and putting it on the tenders. General charges represent a further outlay. The total sum paid by the railway companies for coal cannot be much less than 300,000,000 of dollars, or £60,000,000 per year. The President dealt with the extreme desirability of establishing close relations for mutual benefit between the "coal operators"—that is to say, the colliery owners—and the locomotive superintendents. The following passage, which we quote, may be recommended to the consideration of those who hold that the colliery proprietor does not know how to carry on his business, and is for the most part in disposition a combination of Shylock and a vampire:—"There are a great many problems that the coal operator has to meet at certain seasons and in certain localities. A single grade of coal is in active demand; no one wants the remaining grades. We have recently listened to and read a great deal about the conservation of our natural resources. There is not much consistency in exploiting the conservation of coal when operators at certain seasons are compelled to dump hundreds of thousands of tons of screenings or fine coal on the ground, because the trade at that particular season does not want that particular grade of coal."

The paper and discussion on the first day dealt with the supply of coal from the mines and the method of inspection adopted to secure that it was what it pretended to be, and the conditions under which it might be advisable to buy it, although not just what it ought to be. The most interesting question raised was the value of various systems of testing. No one objected to the laboratory test, save on the one ground, namely, that it might, if the sample were not properly taken—which was the rule—be misleading. But in any case, no calorimeter tests can tell what is and is not a good locomotive coal. Some that gave a very high calorific value in the laboratory was quite unfit for the footplate, because it clinkered heavily. The only true test is that made on the engines; but care must be taken that the driver and fireman are not only competent in a general way, but that they understand the peculiarities of the coal they are burning, and so can make the best of it. As we read we see how wide is the difference in many respects between United States and English practice. With the heavy freight or mineral trains of 1800 to 2000 tons, it appears that "shaking" grates are regarded as necessary evils. Mr. Adams, Superintendent of Motive Power, St. Louis and South-Western Railway, read a short paper, "How to Successfully Burn Locomotive Fuel Coal." Clinkering seems to be the standard trouble. But Mr. Adams told his hearers that the clinkering of coal is due to the manner in which it is handled, and not to the coal. Furthermore, in the course of the discussion which followed we read of fire-boxes partly full of ashes and unburned small coal—a condition so rare in this country that it may be said not to exist. There seems to be much force in Mr. Adams' contention, for coal which with some firemen is extremely troublesome and wasteful, with other men does very well. Thus Mr. Adams read a report from one crew which stated that they were making daily trips over a 131-mile division with engines having 20 by 26 cylinders and dead loads of 2000 American tons. The trip is made in from nine to fourteen hours. The consumption on the run is from 11 to 14 tons of Illinois mine run coal, with sometimes 50 per cent. slack. "We very seldom move grates over four or five times over the division. We very seldom clear out the ash-pan between terminals." We may remark incidentally that this gives an average consumption of about 181 lb. per mile, and about 11 miles per hour. Speaker after speaker insisted on the vital importance of training firemen, numerous instances being supplied of cases in which most remarkable results were obtained by educating the men. The entire volume is full of original information. We have light thrown on the inner working of heavy traffic which is highly suggestive. We must reserve its further consideration for the near future.

The picture unfolded before us displays a very heavy and peculiar traffic for which there is no parallel here, or perhaps in Europe. The quality of the coal depends on the districts through which very long railways run. It appears to be dealt with in an extremely rough-and-ready way at the pits, and no more carefully on the engines. As much of it is small, the air spaces between the bars, or what answers to bars, are narrow. Clinkering takes place, because the coal is not properly fired, and the grates are raked to break up this clinker to let air through; but the clinker is not got rid of, and so at last the fire becomes so dirty that the engine fails for want of steam. If, as seems probable, the new association is able to get firing done better, it will have conferred an enormous benefit on the country.

Engineering, Science, and Business.

Those who take interest in the methods of teaching engineering followed or initiated by the teachers, have not we think, failed to perceive that a considerable change has already taken place in the relations between professors and employers of labour—a change, we may add, very much for the best. At one time the professor looked down on the "practical man," and it is quite certain that the practical man did not look up to the professor. Explanations have long been available. We need not concern ourselves with them. We shall be much better employed in taking things as they are, and reporting progress. It may be said at the outset that little confidence existed between the two classes, for neither quite understood or appreciated the other. The man who was all for a scientific training, which too often meant mathematics and little else, tacitly ignored the circumstance that money and engineering were inseparably connected; while the manufacturing engineer, the contractor, and the steam user held that as the professor knew nothing and cared less about commercial matters, he was not competent to turn out really useful engineers. At home and abroad, in every direction, we find misconceptions being cleared up, difficulties overcome, mutual respect compelled, and the proper values attached to the parts played on the world's stage by both parties. We see, too, that the worth of those qualities which were possessed by the earlier non-scientific engineers is being recognised; and that altogether larger and more intelligent views are being held by men in good positions both as professors or scientists, or as representatives of the multitudes who regard engineering simply as a means of making money.

An example well worth citing is supplied by an address delivered last month in the United States by Dr. G. E. Swain, LL.D., Professor of Civil Engineering in Harvard University, on "The Relation of Engineering to Science and to Business." Professor Swain carefully defined the relation of the profession of engineering to some other vocations. He divides engineering under two heads—Science and Art. "Science teaches us to know, and Art to do. Engineering, then, may be considered as an art founded upon some branch or branches of science, such as the science of mathematics, or the science of physics, or the science of chemistry." One object of the address was to emphasise that in engineering, science is not recognised by the world at large, or even by engineers, as much as the art is, and he goes on to say that the art of engineering is largely empirical, and that it should be the duty of all who have the good of the profession at heart to insist on the science as contrasted with the art. Reading this, it is but natural that we should take it for granted that we have the old stock situation reproduced—the scientist everything, the engineer nothing. But as we proceed we see that there is no justification for such a conclusion. What Professor Swain holds is not that science should assume the upper position, but that the man engaged in the art should give science a fair share of recognition; and we have, for we fancy, the first time in a teacher's address a due insistence on the value of economy. "The engineer must know the laws and forces of nature and the properties of materials, and must be able to apply them economically." He insists on the importance of knowing how to do—that is to say, he rates the art of engineering if possible more highly than he does the science of engineering. We go further, and say that nothing, judging from the world's past experience, is more likely to stultify and incapacitate a man from becoming a useful engineer than the saturation of his brains with pure—that is, unapplied—science. Professor Swain writes with a large experience. He says: "Few of our engineering students really gain the scientific spirit, few of them learn how to reason correctly, most of them are unable to draw correct conclusions from clearly stated premises, and the great majority seem to think that an engineering education is simply learning the rules by which engineering work is done. They inquire simply how, not why; and this attitude is often encouraged by the character of the instruction they receive." This is rather strong language. No doubt it is justified. But is not the situation due in large measure to the circumstance that the teaching is too abstract? and that the connection between what is taught within the walls of a college and what goes on in docks, harbours, and manufactories, our railways and in steamships, is not sufficiently—to use Professor Swain's word—emphasised. In other words, is not the art side of the question kept too much in the background? Professor Swain is quite definite that the proper practice of engineering requires both knowing and doing. But the mere knowing will not enable a man to do, or at least it will not enable him to do economically. Professor Swain sees clearly that the engineer must be distinctly utilitarian. "The scientist may deal with fourth dimensions or other inconceivable vagaries, but the engineer must seek first and foremost the useful." Let any man search his library shelves and make a note of the names of those engineering educational books that make the least reference to the importance of studying economy, or, indeed, regard the profession of engineering in any shape or way from a commercial standpoint. We fancy he will find the list short to a degree that will astonish him. We have not yet got the whole truth in books. We are the more rejoiced to see it advanced in addresses such as those delivered to the Worcester Polytechnic Institution.

It is, however, when Professor Swain leaves the science of engineering for a consideration of its art that he is most instructive. The engineer, he insists, must be very largely a business man. Engineering is business to a very great degree. The engineer deals not only with the design of works, but with their execution and their commercial value. His usefulness will be strictly limited unless he knows how to advise, not only concerning their design, but whether they should be designed at all. He must know how to draw up a contract, how to deal with men, how to smooth difficulties, how to arbitrate when opinions differ, and in many cases how to manage large financial transactions. Is the necessity for the possession of qualifications such as these ever insisted on in technical schools and colleges? Is not the student left to find out for himself, and is he not handicapped in consequence at the outset of his career? We heartily endorse the following passage:—"Engineering is applied science, and its application is directed, in ninety-nine cases out of a hundred, to just one thing—to making money for somebody. No quality will be found of greater value to the engineer than commercial acumen. The young man who looks upon engineering purely as a science, or as the art of applying a science,

independent of business principles, will very likely remain a drudge all his life, directed by men of far less scientific ability, but of greater business acumen." We have preached this gospel for many years, through evil report and good report—very little of the latter. We begin to hope for the best when we find that a leading teacher in a great University does not hesitate to admit that engineering has a commercial side of such overwhelming importance that its neglect may leave a man a drudge all his life.

A NEW FORMULA FOR THE TOTAL HEAT OF STEAM.

By ROBERT H. SMITH.

THERE has been issued this year a new set of steam tables* which differ materially both in matter and in form from the "standard" tables. These latter are inserted in nearly every new book written on steam engineering, the one copied from the other, so that every engineer's library contains more than a score of copies of the same bulky arrays of figures. The figures are exceedingly ancient. They represent excellent work for the age in which they were originated; but since then the means and apparatus of scientific measurement have been almost revolutionised, and many modern first-class pieces of research have revealed material errors in the old experiments. The first efforts towards rectification of the Tables appeared in Peabody's and Robert Heck's works. The new Tables published this year are much more radical in their corrections. They are the result of very laborious, painstaking, and intelligent work by Professor L. S. Marks and Mr. H. N. Davis, of Harvard University, the former a student of this country, although the scene of his labours has now been transferred to the other side of the pond. The tables are the best printed and the most easily read that have been published; they give the quantities for every 1 deg. Fah. temperature and for every 1 lb. per square inch pressure; an extension throughout the whole region of superheated steam covers forty-five pages, and gives the volume, total heat, and entropy. In ten pages in Part II. are given concise explanations of the best ways to use the tables and diagrams. Part III. of twenty pages contains a most interesting and instructive account of all the sources of experimental information from which the new values have been obtained. The book is not only a new valuable aid to accuracy in steam engineering practice, it is also an admirable piece of physical scientific work. Accompanying it are two diagrams of novel construction, the vertical ordinate being "total heat;" and the very considerable practical convenience of this form of diagram for the solution of problems in steam turbine and other high-speed outflow work is fully demonstrated in Part II.

It has long been known to close students of steam physics that the old tables contained practically important errors. In fact, according to well ascertained thermodynamic principles it could be shown that certain parts of the tables were inconsistent with other parts. Until these inconsistencies were eliminated by more accurate modern measurements, it did not seem worth while to take trouble about the exact formulation of the laws of variation of the important steam quantities. The very simplicity of Regnault's expression for the law of total heat, namely, $1082 + .305\ t$, showed that that great physicist did not consider that the accuracy obtained in the measurements justified any very close algebraic analysis of them.

Now that Professor Marks has furnished us with tables that are, in the first place, consistent between their different columns, and that also seem to give data really reliable for comparatively strict accuracy, and now that he has shown what a useful diagram-ordinate the "total heat" may be made, I have endeavoured to analyse the law of total heat algebraically. This has been done by means of a very flexible formula which has been found extremely useful for the accurate representation of a great variety of engineering quantities.

The result has been the discovery of a formula which represents with complete accuracy the figures of the new table throughout the whole range, from 70 deg. Fah. to 500 deg. Fah.; that is, from absolute pressure, $\frac{3}{8}$ lb. per square inch up to 680 lb. per square inch. Below 70 deg. Fah. there is an appreciable difference between the formula and the best experimental measurements; but it must be said that accuracy of measurement of total heat at these extremely low pressures—high vacua in engineering phrase—is very difficult, and it is legitimate to speculate as to whether a formula which fits exactly through so large a range, where measurement is much more capable of exactitude, may not be regarded as being as reliable as the experimental determinations. For example, for the tabular pressure, 0.178 lb. per square inch, the formula gives a total heat less than that in the table against this pressure, and equal to that in the table against the pressure 0.153 lb. per square inch. Now in high-vacuum steam atmospheres there is always an appreciable proportion of air mixed with the steam. It is thus quite reasonable to imagine that the experimental measurement of pressure corresponding to this measurement of total heat was really the sum of the actual steam pressure and of the pressure of the air mixed with it, and that the possibly accurately measured heat was really for a steam pressure much nearer 0.153 than 0.178 lb. per square inch. If one-seventh of the whole pressure, or about $\frac{1}{50}$ lb. per square inch, were due to air, this would completely account for the discrepancy.

In one respect the formula now presented is of startling simplicity, namely, in that it makes the coefficient of the term in t *exactly unity*. The sort of *exactitude* referred to is illustrated by the fact that other sets of constants were tried with this factor made .9938, .997, 1.0066, and 1.055, and that with these factors the formula did not fit the experimental figures nearly so closely. This item of simplicity may have physical significance. The formula is arithmetically convenient in another item, namely, the factor 1,250,000, which is $\frac{1}{8}$th of 10^7. Using it in this divisor form with the help of an ordinary table of reciprocals, it takes not more than half a minute to calculate the total heat for any given temperature. Here again it may be mentioned that in one of the trials this factor became 1,251,150, and this did not fit the desired results nearly so well as $\frac{10^7}{8}$.

Above about 400 deg. Fah. or 230 lb. per square inch above atmosphere, there is as yet no reliable experimental information, so that the tabular numbers, being the result of extrapolation calculations from a formula, have no direct authority.

The formula is—

Total Heat from 32 deg. Fah. of Saturated Steam

$$H = 1826 + t - \frac{1{,}250{,}000}{1620 - t}$$

The following table gives values calculated from this formula, and compares them with those of Professor Marks' new Tables. For more ready intelligibility the tabular pressures as well as the temperatures are inserted:—

Temperature, Fah.	Pressure, lb. per sq. in.	Formula, H.	Marks, Table H.	Difference.
30	.081	1069 9	1072.6	−2.7
50	.178	1079.8	1081.4	−1.6
60	.256	1084.7	1085 9	−1.2
70	.363	1089.6	1090.3	−0.7
80	.505	1094.3	1094.8	−0.5
100	.946	1103.6	1103.6	0
150	3.71	1125.7	1125.3	+0.4
200	11.52	1145.7	1145.8	−0.1
250	29.82	1163.6	1163.8	−0.2
300	67.0	1179.0	1179.1	−0.1
350	134.6	1191.8	1191.5	+0.3
400	247.1	1201.4	1201.3	+0.1
450	421	1207.6	1208.0	−0.4
500	684	1209.9	1209.0	+0.9
600	1574	1200.5	1176	+24.9

The small + and − differences indicate, of course, that these are within the range of probable error in the tabular figures. This means that from about 70 deg. or 80 deg. to about 500 deg. the agreement is complete.

If the specific heat of water were constant, then the term t would, of course, represent solely and completely that part of the heat spent in heating the water, and the remainder, namely, $1826 - \frac{10^7}{8(1620 - t)}$, would be the heat of evaporation. Professor Marks' book contains an interesting discussion of some of the various meanings that may be given to the phrase "specific heat of water." According to the definition he adopts as most practically convenient, the specific heat varies from a minimum of 0.997 at about 100 deg. Fah. up to 1.041 at 340 deg. or 120 lb. per square inch pressure.

In this country 58 deg. Fah. may be taken as a good average for the *fresh* feed to a boiler. If H be reckoned from this temperature, then 1800 would be substituted for the constant 1826 in the formula; and this 1800 is a number easy to remember.

*Tables and diagrams of the Thermal Properties of Saturated and Superheated Steam. By L. S. Marks and H. N. Davies. Longmans Green and Co. 1909.

LITERATURE.

Die Crampton-Lokomotive mit Besonderer Berücksichtigung der Deutschen Bauarten. Eine Historich-Technische Abhandlung. Von F. Gaiser. Neustadt a.d. Haardt. 1909.

WE can assure those of our readers who are interested in locomotives that they will do well to purchase this book, even though their knowledge of German is exceedingly small. The drawings and photographs which it contains are admirable. They include sectional drawings to a good scale, fully dimensioned in many instances, and external views in black and white, which make the general appearance as well as the details of construction quite clear and intelligible. Furthermore, there are numerous tables giving minute information as to dimensions. The treatise is in every way complete so far as drawings and description can make it. Also, the book is beautifully printed on excellent paper. There are 85 pages, 51 engravings arranged in plate pages, and a number of photographic reproductions and wood engravings. The book is 12¼in. by 9in.

The Crampton locomotive met with favour from the first in France, and until a comparatively recent period it retained its popularity. Many of our younger readers have no doubt never seen a Crampton engine, and for their benefit we may say that it was a locomotive with a large and long boiler and a single pair of driving wheels from 6ft. to 8ft. in diameter, the axle of which extended across behind and as close as possible to the fire-box. The first engines had a single pair of leading wheels close to the smoke-box, and a third pair, the axle of which lay in front of the fire-box. This arrangement was sometimes modified subsequently. The cylinders were outside, as was the Stephenson link valve gear. The cylinders were bolted to the frames about midway of the length of the boiler. In some cases the engine was very handsome; in others it was spoiled by huge and unsightly excrescences in the shape of domes and safety valves. The whole type was just the thing to take a Frenchman's fancy. He liked to have everything under the eyes of the driver and readily accessible for lubrication and repairs, and we have no doubt that these were the principal reasons for the spread of this type over France, and thence, very naturally, over Belgium and into Germany.

Thomas Crampton was born in Broadstairs in the year 1816. We find him working on the Great Western Railway in 1842. He took out his first patent in conjunction with John Coope Haddan in 1850-51. He played a leading part in the laying of the first undersea cable, which ran from Dover to Calais. He died on the 19th of April, 1888, and was buried in Kensal Green. Those who desire further particulars of a busy and influential life will find them in our pages at that date.

The book before us is a history not of the man, but of the Crampton locomotive, compiled with much care from data never before published. The first Crampton locomotives built were the Namur and Liège, in 1846, by Messrs. Tulk and Ley, Lowca Works, Whitehaven. They had 16in. cylinders, 20in. stroke; the driving wheels were 7ft. in diameter; the carrying wheels 3ft. 9in.; the total wheel base 13ft.; the boiler pressure 90 lb. There were 192 tubes, 2in. in diameter, and 11ft. long. The grate was 4ft. 3in. long by 3ft. 5in. wide; the total heating surface 989 square feet. The total weight was only 22 tons, of which 10.5 tons were carried by the drivers. Following these, locomotives were built for many lines, differences being introduced to suit varying conditions, and the wish of the companies, but in all the type remained constant. There were always outside cylinders, about midway of the length of the boiler, with the driving axle behind the fire-box. In 1851 an exception was made in a locomotive built for the South-Eastern Railway. The engine was carried on a leading four-wheeled bogie, and a pair of driving wheels as usual, with the axle close behind the fire-box; but the cylinders were inside, and turned a crank shaft, which had no wheels, and drove the driving wheels by outside coupling rods. It was in no way a success. The most noteworthy English Crampton engine was the Liverpool, commonly called the Great Liverpool. This engine was built in 1847, at the time of the Battle of the Gauges. It was maintained that it was impossible to build an engine for the 4ft. 8½in. gauge as powerful as Gooch's Great Western 7ft. gauge locomotives. The Liverpool was the reply to the Iron Duke. The principal dimensions of both are given in the annexed table:—

	7ft. gauge. Iron Duke.	4ft. 8½in. gauge. Liverpool.
Cylinder diameter	18in.	18in.
,, stroke	24in.	24in.
Driving wheel	8ft.	8ft.
Wheel base	18ft. 6in.	18ft. 6in.
Boiler pressure	100 lb.	120 lb.
Tubes, number	303	300
Length	11ft. 6½in.	12ft.
Heating surface—		
Fire-box	147.87 square feet	154 square feet
Tubes	1797.1 square feet	2136 square feet
Total	1945 square feet	2290 ,, ,,
Grate surface	21.66 square feet	21.5 square feet
Weight	35.5 tons	35 tons

Nothing is more striking about these engines than their very small weight and enormous heating surface. The Liverpool attained, it is said, a speed of 79 miles an hour in January, 1848. It did not continue long in service. The wheel base was too much for the light permanent way. But it settled once for all the dispute as to the relative capacities of the broad and narrow gauge. Crampton could do anything that Gooch could accomplish.

Herr Gaiser's illustrations and descriptions cover a great deal of time and a great deal of space. Few modern engineers have an adequate conception of the number of Crampton engines constructed for continental railways. Many of them were very handsome. They looked like fliers. We may cite as an example the Badenia, built for the Badeschen Staatsbahn in 1863. Quite as elegant in design were three locomotives, Nos. 81, 83, and 85, built in 1849 for the South-Eastern Railway. The Crampton system found its way to the United States, and Herr Gaiser gives us an engraving of an extraordinary machine, which looks like a combination of a gipsy van and a traction engine. It was built for the Camden and Amboy Railway. It had an enormous spark-catcher conical chimney, little less in diameter at the top than the boiler barrel. It was built in 1849 by Richard Norris and Sons, Philadelphia. It had cylinders 13in. diameter, with the enormous stroke of 34in. The boiler had 98 tubes 2in. diameter and 12ft. long. The grate was 5ft. by 4ft., and there were about 730 square feet of heating surface. The pressure was 90 lb. Contrasted with this may be mentioned the little Lightning, built in 1849 for the Syracuse and Utica Railway. But for the disproportionate dome this was a beautiful engine, carried on a four-wheeled bogie, a pair of intermediate wheels and drivers. No particulars are given of its dimensions.

It is interesting to examine the detail drawings, particularly of the boilers, and to note how the best modern practice seems to have been anticipated half a century ago.

Herr Gaiser has done his work very thoroughly. He seems to have verified all his dates, and nothing more complete can be imagined than his tables of dimensions. The book concludes with a very intelligent criticism of the Crampton engine. It was impossible to get sufficient weight on the drivers to secure the adhesion necessary to draw heavy trains and utilise the steaming powers of the boilers. The Crampton engine has disappeared because it possessed no specially advantageous characteristic. At the time it was invented, however, it enabled a bigger boiler to be used than was deemed to be possible with any other type on the narrow gauge, and beyond doubt it did much to determine the general adoption of the 4ft. 8½in. gauge, instead of that of the Great Western.

THE INSTITUTION OF CIVIL ENGINEERS: NEWCASTLE-UPON-TYNE ASSOCIATION OF STUDENTS (SESSION 1909-1910).—We are informed that the secretarial duties of the Institution have now been taken over by Mr. E. D. Case, 1, Beaufront-terrace, South Boldon, to whom all communications should be addressed.

ORDNANCE ATHLETIC CLUB.—A smoking concert was held on Tuesday evening at King Edward VII., New Corporation-street, Birmingham, in connection with the Football Section of the Works League of the Electric and Ordnance Accessories Company, Limited, between three and four hundred of the staff and workpeople being present. The evening was a great success.

RECENT LOCOMOTIVES ON THE PARIS, LYONS, AND MEDITERRANEAN RAILWAY

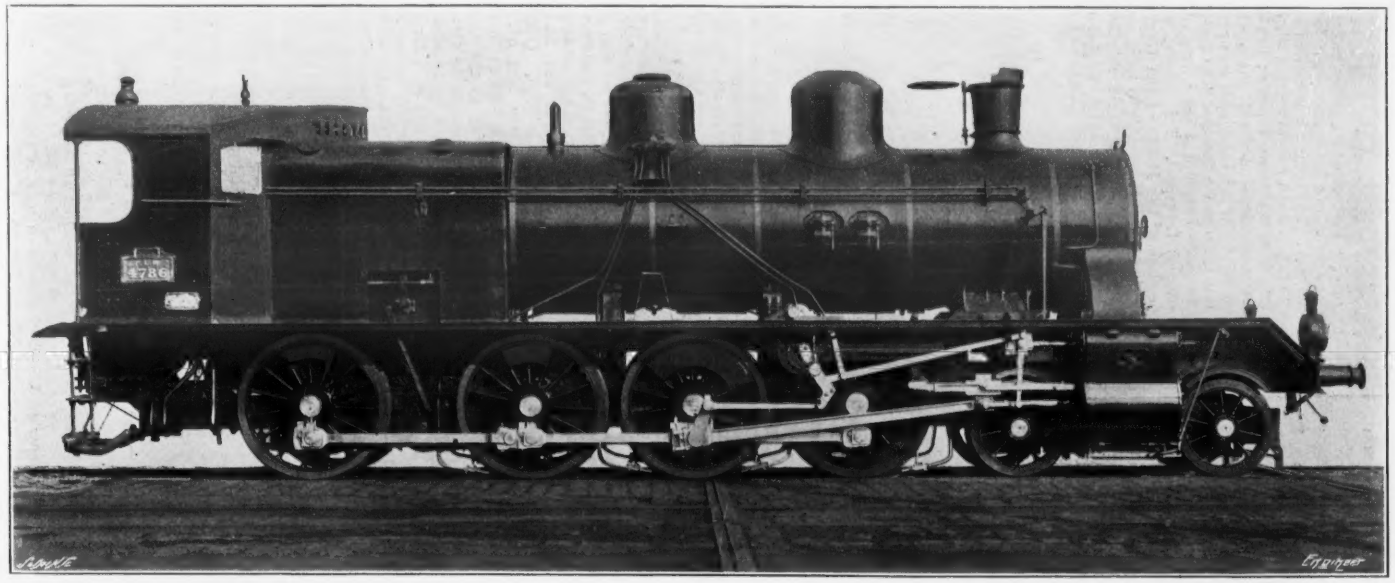
(For description see page 669)

Upper Engraving:—

EIGHT-WHEELS COUPLED

FOUR-CYLINDER

COMPOUND GOODS ENGINE

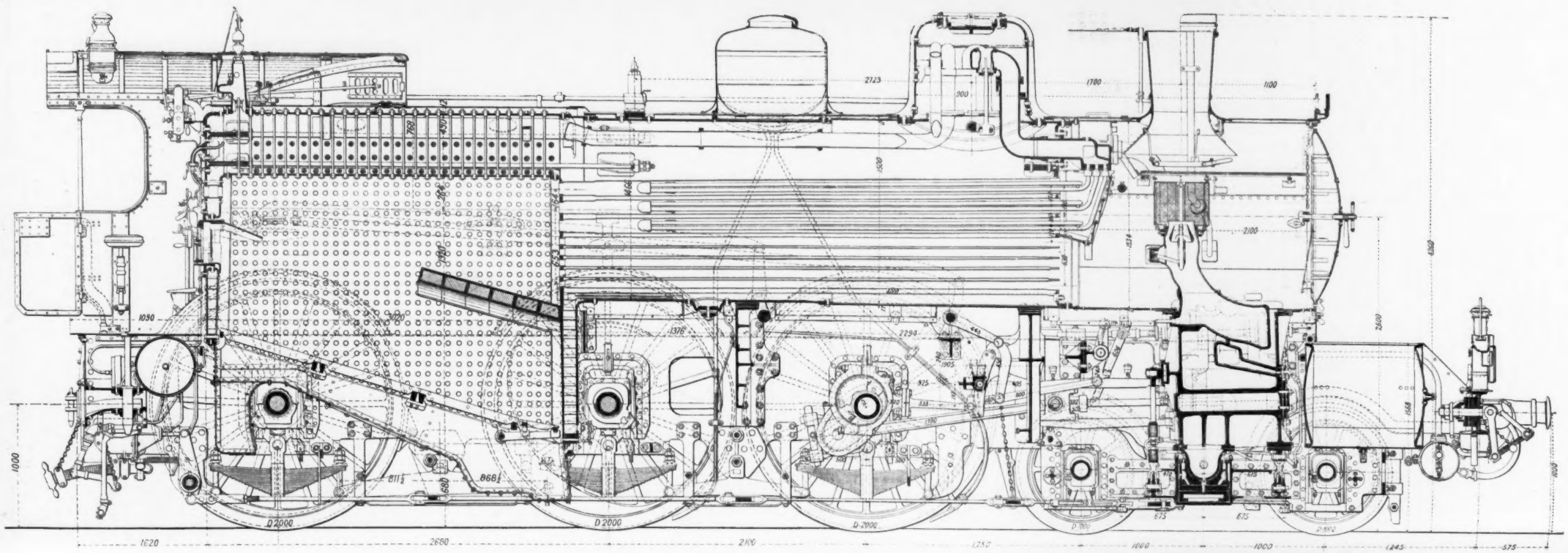


Lower Engraving:—

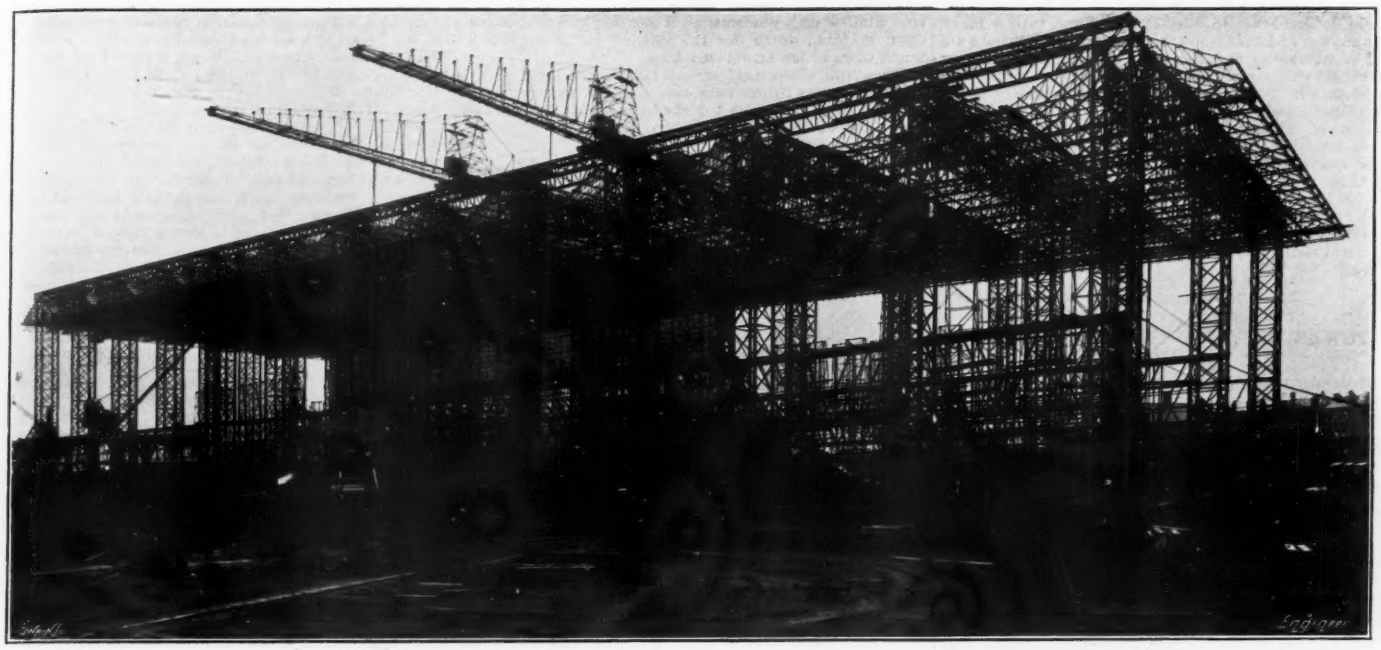
EXPRESS PASSENGER LOCOMOTIVE

FITTED WITH

SCHMIDT SUPERHEATER



SHIPBUILDING BERTHS AND CRANES AT THE WALLSEND SHIPYARD



NEW FRENCH LOCOMOTIVES.

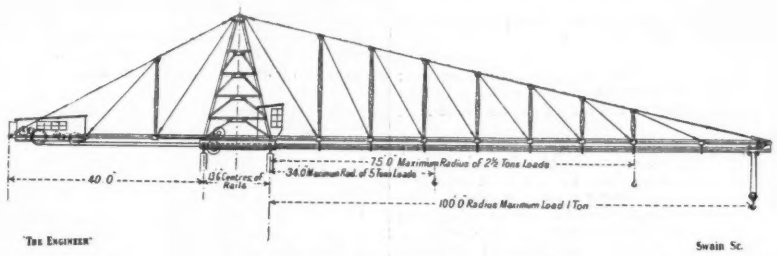
WE are enabled, through the courtesy of M. Chabal, locomotive superintendent of the Paris, Lyons, and Mediterranean Railway Company, to reproduce a photograph of the latest goods engines for this railway. The engine illustrated is a four-cylinder compound with a boiler similar to that of the tank engine series 5500, illustrated in our issue of June 4th last. The steam pressure is 225 lb. per square inch, and the driving wheels are 59in. diameter. These engines have been specially designed for heavy service on the main line, and with a view to avoiding double heading on the section from Les Laumes to Dijon, where the ruling gradient is 1 in 125. Their loading on this section is about 830 tons at a speed of 15 miles per hour, while on the easier sections the load is the same, but the average speed is to be raised to 25 miles per hour, and the maximum speed authorised is 48 miles per hour. The system of compounding adopted is that of the late M. Baudry, locomotive superintendent of the company, and a great feature of it is that the admission in the low-pressure cylinders is fixed at all speeds at only 60 per cent.; this is the theoretically correct point with this system.

A few of these engines are fitted, for trial, with Schmidt superheaters, as are ten of the big 4–6–0 express engines Nos. 2691-2700. The superheater, which is worked at 330 deg. Cent., is giving good results. These engines take the place of the 4500 class of 0–8–0 engines, which, owing to all their wheels being coupled, were very limited as to speed. However, this 4700 class of engines, with their 4–8–0 wheel arrangement, are admirably steady at all speeds, while they are even more powerful than the 4500 class. The engines are most comfortably fitted with spring seats for the men, but the temperature of the cab is unpleasantly high, and modifications will no doubt be made, as has been done to the tank engines.

We are enabled also to give a drawing of one of the most recent express engines fitted with a Schmidt superheater. The chief point so far noticed is a decided economy of water, while the engines appear to run more freely at high speeds than with saturated steam. It is too early to give any decisive figures, but so far the results are satisfactory. We hope later to be able to give detailed figures and performances.

NEW CANTILEVER CRANES AT THE WALLSEND SHIPYARD.

THERE has previously been described and illustrated in THE ENGINEER the large glass-roofed structure covering two of the shipbuilding berths at the Wallsend Shipyard. These sheds, from one of which the Mauretania was launched, are each about 740ft. in length and 150ft. high, the clear width inside the two berths being 100ft. and 95ft. respectively. The engraving on the top of this page is, however, reproduced in order to show more particularly the two cantilever cranes which have quite recently been erected on the top of the sheds. These cranes consist of a central truck with an elevated tower from which depend heavy steel cables, extending to the extreme end of the jib and also to the tail part which carries the machinery and ballast. Special care was exercised in the design of the cranes, so as to make them as light and as strong as possible. The front cantilever is constructed of steel tubes supported at intervals by vertical lattice columns of steel. The length of the cantilever jib is approximately 100ft., while the tail part has a projection of 40ft. The cranes will lift 5 tons up to 34ft., 2½ tons up to 75ft., and 1 ton up to 100ft. distance from the front rail. The work they will have to do is to deal with steel plates and sectional material for the construction of floating docks and ships, and they will very shortly be brought into use in laying down of the large "box" type connection with the pontoon floating dock, of 32,000 tons lifting capacity, the order for which has recently been placed by the Admiralty with Swan, Hunter and Wigham Richardson, Limited. The cranes have three separate sets of electric motors for hoisting, racking and travelling. Direct current electricity at 240 volts is conveyed by two trolley wires running the whole length of the slips. Hoisting is done by a 25 horse-power series-wound motor with powerful electrical and mechanical brakes, the rope being coiled on a very large drum. There is also an over-winding device to prevent the pulley block being lifted too far. The racking motion is driven by a 5 horse-power motor with electric brake. The travelling motion is worked by a 25 horse-power motor with both electric and mechanical brakes. The hoisting speed for 5 tons is 60ft. per minute; lighter weights are lifted more quickly to a maximum of 150ft. per minute. The racking speed is 60ft. per minute loaded, and the travelling speed, when the crane is loaded, is 400ft. per minute. An ingenious device has been fitted by means of which, so soon as an excessive load is applied, an automatic switch in the driver's cabin comes into operation and instantly prevents the load from being lifted or racked outwards, although permitting of the load being lowered or racked inwards. Elaborate means have also been provided to prevent any possible derailment. These cranes were manufactured by Joseph Booth and Brothers, Limited, of Rodley, near Leeds, and the girder track on which they run was designed, constructed, and erected by Swan, Hunter and Wigham Richardson, Limited.


75'0" Maximum Radius of 2½ Tons Loads
34'0 Maximum Rad. of 5 Tons Loads
40'0"
0'6" Centres of Rails
100'0 Radius Maximum Load 1 Ton
"THE ENGINEER"
Swain Sc.

OUTLINE OF THE CANTILEVER CRANE

THE KIEL DOCKYARD SCANDAL.

(By a German Correspondent.)

THE Kiel Dockyard scandal has now received decent burial. After—for Germany—an unprecedentedly long trial of five weeks' duration, during which the public prosecutors entirely failed to make good their case, the jury returned a verdict of "Not guilty" on every count in favour of the four officials and five merchants accused. An appeal made against this finding has been withdrawn again, and, whatever may be thought of the merits of the inquiry, it is difficult to see how the somewhat broadly-made charges could be substantiated, or what good purpose such substantiation would serve. The defence of the dockyard system has since been undertaken by the Minister of Marine, Admiral Tirpitz, before the Reichstag, who showed that during the trial the naval administrators had had no opportunity of defending themselves, and that, though certain individuals had proved unworthy of the confidence placed in them, the counter-charges made by the acoused merchant Frankenthal of want of system amongst the officials generally were undeserved, or at any rate overdrawn. That abuses existed was not denied.

The trial itself, which has been watched with close interest in the country, has thrown cross lights on some German methods which are not without a certain interest of their own.

The Kiel Dockyard is a very extensive establishment, which, as shown by Oberwerftdirektor Admiral von Usedom, of Seymour Expedition fame, must be looked upon principally as a place for the repair and maintenance of the fleet. The object in life of the yard is thus not to make or save money, but to get the vessels that come in for succour ready for sea again in the shortest possible space of time. Even in time of peace night-and-day work has often to be resorted to, and the comparative neglect given to the small percentage of the whole turnover represented by the value of the scrap material is under such circumstances not altogether without its justification. When a large repair has been accomplished with all possible dispatch, and another one is in view, the yard clears for action. The tendency is to throw everything superfluous overboard, as in the case of a warship in presence of an enemy. Higher interests are at stake than scrap iron, and if the children of Abraham, who for a consideration remove this encumbrance, grow rich over the transaction, it may be no more unprofitable to the nation than the employment of a number of additional sub-officials to cope with the buyers and the extra demands made on the time of superiors for their control.

Broadly speaking, the history of the case is as follows:—A number of merchants with Asiatic-sounding names were accused of bribing some of the subaltern officials of Kiel Dockyard to allow them to take away larger and more valuable amounts of scrap material than they had really bought. The head storekeeper and other officials were likewise accused of taking bribes in this way and of generally aiding and abetting the machinations of the merchants. At the outset of the trial, Herr Frankenthal, one of the merchants accused, in the course of his examination made counter charges against the administration of the dockyard, which he said was conducted with an incredible degree of absence of business method. The inference was that, in the face of such conditions, merchants like himself were to be excused for making the most of chances of profit making, which were quite favourable enough without any resort to bribery.

Comparisons made between the weights of scrap material booked by the yard as sold and those noted by the railway officials as forwarded over the line showed discrepancies which, though large in themselves, were much less than the amounts credited by the public prosecutors to the merchants as wrongfully received by them. Further there was at least a doubt whether the railway weights themselves could be strictly relied upon, and it was also shown that the dockyard made a deduction for dirt accompanying the scrap, which appeared to be not altogether unfair.

A good illustration of the general question at issue was the case of a discarded steel mast, which had been sold for about £4 to Herr Frankenthal and resold by him for about £50. The manager of the yard, Admiral von Usedom, explained that the mast was a welded one, which, with the means then available, could not have been cut up into scrap for less than £45, and the carriage of which was necessarily very expensive. Every effort had been made to find a suitable use for it without avail, and its sale for the small sum named was justified by the circumstances.

The popular feeling, backed up by newspaper articles and

utterances of certain naval officers, is that the imperial dockyards employ too many officials for the work to be performed, and that their thorough reform is desirable, while the appointment in them of a good proportion of men of business is advocated. Also comparisons are made with the numbers of officials and workmen in the royal dockyards in England. Compared with the vessels to be dealt with, the German dockyards are in some cases credited with a much larger number of hands employed; but such comparisons are apt to be misleading, and, as regards the officials, the higher numbers are partly explained by the system of control above referred to, which also necessitates more book-keeping in the dockyards themselves. The Admiralty has declared its intention of instituting reforms in its own way. In view of revelations at the trial, certain of the officials of the old material department are said to have been removed from their posts, but, according to the speech of Admiral Tirpitz in the Reichstag, the charges against the administration of the dockyards go much too far, and thoroughgoing alterations are not contemplated, except in the old material department itself, where the same trouble is hardly likely to occur again.

POWER TESTS OF MACHINE TOOLS.

By P. V. VERNON.*

THE development of machine tools during the last few years has taken place principally in two directions—first, in the speeds at which they must be capable of running to enable high-speed steel tools to be used up to their limit; and, secondly, in their general design, so as to permit of more easy handling, of taking heavier cuts, and of increased accuracy in their product.

The result of this development has been that, quite apart from the question of high-speed cutting, our present-day tools are better tools, and will produce a greater output, and with a higher degree of accuracy, than formerly, even using the old carbon steel cutters.

In an article I contributed to THE ENGINEER of March 13th, 1908, the dimensions, weights, and powers of ten milling machines of similar nominal capacity, but by different makers, were compared, and it was shown that there was no agreement whatever among the various makers on the questions of the power to be provided and of the weights of the nominally similar machines. As a matter of fact, the figures showed that the heaviest machine of the ten had the least power—in fact, had less than one-third of the power provided by the most powerful machine of the ten, and the powers of the remaining machines were fairly evenly distributed between the high and low limits. The natural inference was that machine tools in many cases were not designed scientifically, or, in other words, their proportions were not determined from experimental researches; and it was owing to a conviction that this was the case, and to a lack of reliable data, that the experiments described in this lecture were undertaken.

It must be understood that the tests to be described have been selected from a very large number that have been made with machines of varying size and type, and also that they are not laboratory tests bristling with microscopic and micrometric refinements, but are practical tests of the kind needed by the designer who has to produce commercial machines in a reasonable time.

The first set of tests was made on a horizontal milling machine, and was published in full in THE ENGINEER of March 19th of this year; but the second set, which relates to a hexagon turret lathe, are entirely new, and have never previously been published.

The broad objects of both sets of tests were to obtain by experiment reasonably exact knowledge of what each machine would do, so as to establish a basis from which the designs of the machines might be improved and their productive powers increased.

In detail, the objects of the tests were:—(*a*) To ascertain the power consumed on different cuts; (*b*) to ascertain the relation between power consumed and output produced; (*c*) to ascertain the best way of producing the highest output; (*d*) to check the efficiency of the driving gear of the machine; (*e*) to discover weak points in the design or construction of the machine.

The tests were made in the private experimental workshop of Alfred Herbert, Limited, the machine being driven by a jackshaft, which in turn was driven by belt from a variable speed motor, installed specially for testing purposes. The motor was of 15 horse-power, the speed variation being from 330 up to 990 in a large number of steps. It was found possible to run the motor up to 30 horse-power for quite long enough periods for the cuts which were taken, and the efficiency of the motor was known at all speeds and loads, the actual brake horse-power being thus easily computed from the electrical readings.

The jackshaft ran on roller bearings, and the power required to run the jackshaft light was measured and deducted from the total horse-powers. The power consumed by the jackshaft when under load could not be measured, but it was assumed that the increase under load would be small, owing to the efficient type of bearing, and to the observed fact that the temperature of the bearings did not rise appreciably during the tests.

The second set of tests were made on a No. 2 hexagon turret lathe, made by Alfred Herbert, Limited, the motor and driving arrangement being the same as before, except that no overhead countershaft was used, the machine being driven direct from the jackshaft.

The lathe was run 25 per cent. faster than its standard speeds for the purpose of these tests. The height of centres was 8in., diameter of single pulley 12in., width of belt 5in., and speed of pulley 500.

Fig. 1 shows the tool holder with its roller steadies and the side cutting tool, the section of which was 1in. by ¾in. The cutting tools were made of "special" high-speed steel, the cutting angle being 48 deg., except on some of the lighter cuts, when a slightly greater angle was found to be better.

Fig. 2 shows the relative positions of work, cutter and steadies, and illustrates in a very graphic manner the way in which the metal is removed, and also the way in which the work is supported while being turned. The material on which the tests were made was mild steel of about 25 tons tensile strength, 15 tons elastic limit, and 44 per cent. elongation.

* From a paper read before the Coventry Engineering Society on November 19th.

The method of making the tests was to begin with the largest bar the machine would admit, and to reduce it at one cut 1¼in. in diameter, the depth of cut being, of course, ⅝in. At this cut various speeds and feeds were tried, the speeds naturally having to be reduced as the feeds were increased.

A similar set of tests was then made, reducing the bar 1in. in diameter, and then reducing it ⅜in. in diameter, and so on. Similar tests were made on smaller bars progressively down to 1¼in., which was the smallest bar it was thought worth while to test on this machine.

The results of the tests were all kept in detail, but as there are far too many figures to be carried in the memory, it will, perhaps, be best to point out the leading facts and the chief deductions which can be made from them.

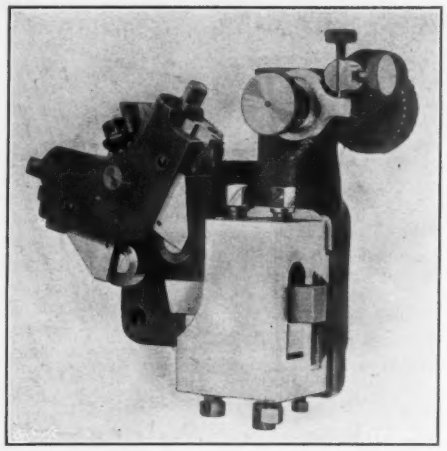


Fig. 1—ROLLER STEADY AND TOOL HOLDER

Maximum output.—The table below gives the six best results, and it should be understood that no tests are recorded in which either the machine or the tool failed.

Number.	Reducing From	Reducing To	Speed per minute.	Feed per minute.	Metal removed per minute. cubic in.	Metal removed per minute. lb.
	in.	in.	ft.	in.		
1	2¼	1	190	11⅜	36.29	10.16
2	2	¾	252	15⅜	36.11	10.11
3	1¾	½	184	16⅛	35.52	9.94
4	2	1	210	14½	35.04	9.81
5	1¾	½	229	17½	34.79	9.74
6	2¼	1	236	10⅝	33.89	9.49

The leading fact to be gleaned from this table is the remarkable one that it is possible on the hexagon turret lathe to remove as much as 10 lb. of metal per minute from so small a bar as 2in. using only one tool, and it is more than doubtful whether such results have ever before been obtained on any type of machine tool.

Power consumed.—The maximum horse-power consumed was 23.7 in the case of Test No. 2, viz., the test on the 2in. bar just referred to. Ten years ago the lathe in its then form used to be sold with a 2 horse-power motor, whereas a 20 horse-power motor would now be required if such cuts were to be taken continuously. As a matter of fact, such heavy cuts never last very long, on account of the great rate at which the work is done, and a 10 horse-power motor is generally large enough for the lathe, its overload capacity taking care of the heavy cuts. Still, an increase of from 2 to only 10 is not to be sneezed at if the output is in proportion, as the tests indicate.

Ratio of metal removed to power consumed.—In the whole of the tests the metal removed per horse-power minute varied from .33 lb. on the lighter cuts to .52 lb. on the heavier cuts,

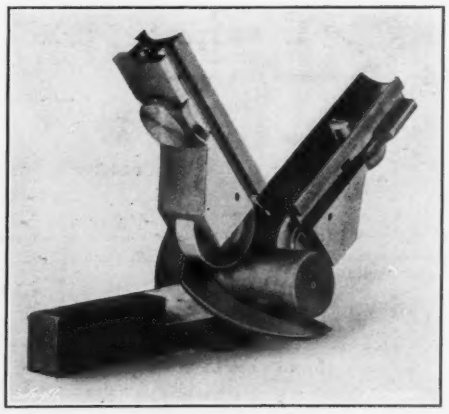


Fig. 2—RELATIVE POSITIONS OF CUTTER AND STEADIES

showing the combined efficiency of lathe and tool as a cutting apparatus to increase with the output. In order to compare these figures with those obtained by other experimenters, the following table has been prepared from the Manchester experiments made in 1903, cutting soft steel of somewhat similar quality to that referred to above.

Material Removed in Pounds per H.P. Minute.

	Horse-power.	lb. per min.	lb. per H.P. min.
Alfred Herbert, Limited, No. 2 hexagon turret lathe, 1909.			
Highest figure	14.4	7.58	.52
Lowest figure	6.1	2.01	.33
Manchester experiments, 1903 (pages 273, 298, and 308).			
Highest figure	8.94	4.41	.49
Lowest figure	17.19	5.6	.32

The similarity of the figures would be remarkable were it not for the fact that the Manchester figures represent nett horse-power at the tool with the losses in the machine deducted, whereas the figures now submitted include all losses in the machine, and, therefore, would indicate a considerably higher net efficiency at the tool. This assumption is borne out by the figures which follow.

It is to be regretted that the particulars published by Mr. F. W. Taylor in his "Art of Cutting Metals" do not permit of a similar comparison being made, but, as Taylor's determinations of tool pressure agree substantially with the Manchester results, it may be assumed that his efficiencies would not be very much different.

Pressure of chip on tool.—The next table shows the comparative tool pressures in the Manchester experiments, those of Mr. F. W. Taylor, and Alfred Herbert, Limited, and it will be noted that the pressure on the hexagon turret lathe tool was very much less than in either of the other examples, showing that it cut more easily and required less power. The steel operated on was a little softer, judging by the tensile strength, but the elongation was greater; and it has been shown by Taylor ("Art of Cutting Metals," page 150, paragraphs 508-509, and page 151, table) that softer steels often cut with higher pressure than harder steels if the elongation is greater. In any case, the difference in pressure was much greater than could be accounted for by the lower tensile strength, and existed in spite of the higher elongation.

Pressure of Chip on Tool.

	Tensile strength, tons per sq. in.	Elongation, per cent.	Pressure on tool, tons per sq. in.	Losses in machine deducted.
Manchester experiments, 1903 Report, pages 152, 298, and 308	26	25	115	Yes
	29	26	108	Yes
F. W. Taylor ("Art of Cutting Metals," 1902, page 164)	30	29	107	Yes
Alfred Herbert, Limited, 1909*	25	44	74.9	No

* Best result, reducing 2¼in. to 1¼in. at 151ft. per minute, twenty cuts per inch, absorbing 14.4 horse-power, including losses in the machine.

CONCLUSIONS.

1. The maximum amount of material removed was 10.161b. per minute.
2. The maximum horse-power that could be utilised was 23.7.
3. The maximum amount of material removed per horse-power minute was .52 lb.
4. The highest cutting speed that could be utilised on high output was 295ft. per minute.
5. The highest speed provided (500) could be advantageously employed on the largest bar admitted (2¼in.), and on all smaller bars.
6. The quickest feed available on the lathe (23⅝in. per minute) was used on a 1¾in. bar running at the highest speed provided, viz.—500, with a cut ¼in. deep.
7. The minimum tool pressure is about 75 tons per square inch, against about 100 tons according to other experimenters.
8. The large output and high efficiency of the tool is primarily due to its small cutting angle.
9. The successful action of the tool on such small bars depends upon using an efficient steady.
10. The maximum results could not be reached with any but a roller steady.
11. Modern machines for bar work must have ample speed range, ample driving and feed power, a rigid machine and ample room for chips, also a liberal supply of cooling liquid.

BUENOS AIRES EXHIBITION, 1910.

IN celebration of the 100th anniversary of the proclamation of the independence of the Argentine Republic, which occurs in May next, the Argentine Government have decided to organise in the capital a series of commemorative exhibitions, congresses, and festivities The exhibitions officially recognised by the Argentine Government will be five in number:—(1) The Railway and Land Transport; (2) the Agricultural and Live Stock; (3) the Hygienic; (4) Art; and (5) Industrial—confined to Argentine products only. In addition to these, there will be an exhibition promoted by the Liga de Almaceneros under the name of the Universal International Exhibition.

The first of these—the Exhibition of Railway and Land Transport—is important from the point of view of manufacturers of railway rolling stock, of tramway material, motor cars or vehicles connected with other means of locomotion. Covered areas have been assigned to the various nations who are taking part, including Great Britain, Germany, Austria, Italy, Belgium, France, and the United States. According to the latest information received from the Commissioner, the area definitely allotted to Great Britain in the Railway and Land Transport Exhibition is 15,000 square metres. An option has, however, been secured upon an additional area of 3000 square metres. Of the other nations Germany had been assigned 6000 square metres and the United States 3500.

On his arrival in Buenos Aires, the Commissioner found that a good deal of preliminary work had been done by the various manufacturers' agents and railway authorities, under the guidance of Mr. Townley, the British Minister, but it remained for him to collate the various individual efforts that had been made, and to secure the necessary facilities for British exhibitors. It is understood that the buildings for this Exhibition are now well on their way to completion, and that most of the space has been already allotted, the last date on which applications can be received being the 31st December.

A special catalogue of the British section will be printed, a reading room will be provided, and other matters of detail tending to facilitate the task of exhibitors of installing their exhibits in the Exhibition are receiving attention. The Exhibition grounds are in a favoured district of the city of Buenos Aires, facing the Palermo Park, and adjacent to the racecourse.

As in the case of the Brussels, Rome, and Turin Exhibitions, the management of the British section of the Buenos Aires Exhibition is in the hands of the Exhibitions Branch of the Board of Trade, and all information can be obtained from the Director of the Branch, 30, Broadway, Westminster, London, S.W.

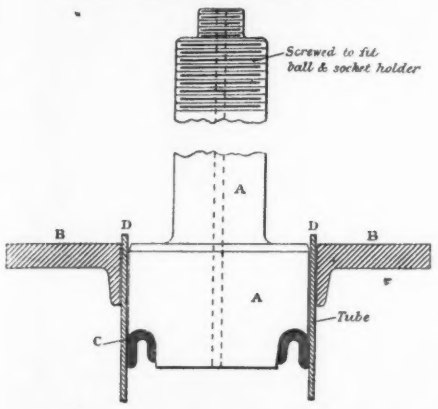
MILD STEEL TUBES IN COMPRESSION AND UNDER COMBINED STRESS.*

By Mr. WILLIAM MASON, Associate Member,
of the University of Liverpool.

Preliminary.—One of the most important contributions during recent years to our knowledge of the strength of materials is the paper by Mr. J. J. Guest on "The Strength of Ductile Materials under Combined Stress." The experimental results and the conclusions deduced have gradually been brought to the notice of engineers, and it is only necessary to re-quote Mr. Guest's practical conclusion, namely, "That the condition for initial yielding of a uniform ductile material is the existence of a specific shearing stress." This result, if true, must be of great practical importance; for in all cases of stress—with the exceptions of positive and negative fluid stress—there is shear stress induced over certain planes.

FIG. 1.

Method of Holding Tube End during Tension.



Other investigators† have made experiments in combined stress which are confirmatory of Mr. Guest's conclusion. So far as the writer is aware, very little work has hitherto been done in which the compressive stress has been much greater in intensity than the other stresses. In Mr. Guest's tests a principal stress, when compressive, never exceeded the other principal stress in intensity. Mr. Scoble did work on bars under bending and torsion, in which the yield may have been due to the stress on either the compressed or extended side of the bent bar. And Professor Hancock's reports only contained seven tests on simultaneous compression and torsion.

Object and scope of the experiments.—The work described in this paper is largely upon comparative yield-point strengths in compression and shear; though in some cases the stresses have been carried as far as the rupture or collapse of the material. In making tests in compression it is essential that the force shall be

Fig. 2

axial to the specimens. It appeared to the author that this condition might be attained, approximately at any rate, by the apparatus hereafter described, using tubes as specimens; and that, as in Mr. Guest's experiments, a second stress, at right angles to the direction of the compression, could be conveniently imposed by hydraulic pressure in the interior of the tube. Besides the sets of tests in simple compression and in simultaneous compression and hoop tension, three series of tests were made on certain of the tubes under conditions as follows, namely:—Tests under simple axial tension, simultaneous axial and hoop tension, and simultaneous axial and hoop compression.

Material for tests.—The specimens were cut from solid-drawn mild steel tubes. Two sizes of tubes were used, namely, 3in. bore, 14 gauge (about 0.08in. thick), and 2⅜in. bore, 10 gauge (about 0.128in. thick), the former being cold drawn and the latter hot drawn. Various lengths of specimens of each of these were

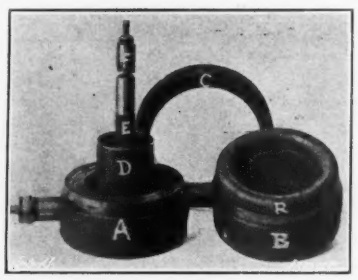


Fig. 3

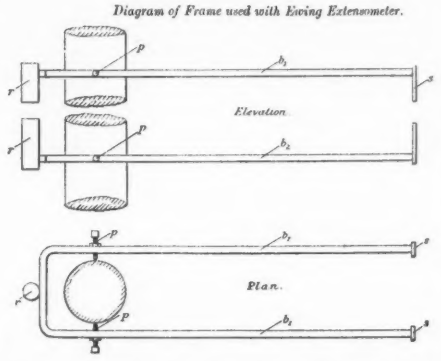
tested, the lack of uniformity noticeable in the lengths being due to the circumstance that it was difficult to cut, from the same piece, the required lengths of exactly straight tubes. Most of the tubes were supplied by the British Mannesmann Tube Company. They had undergone some degree of annealing, but not so far that they could be considered isotropic for the purpose of the tests. Experiments were made on the tubes both in the condition as supplied and also after further annealing. The latter was done by encasing the tubes in a longer tube of rather larger diameter, the ends of which were blocked up with asbestos and fire-clay. The tube and the outer casing were kept from contact by narrow rings of asbestos. The whole was placed in a coke furnace at a temperature of from 800 deg. Cent. to 850 deg. Cent., and allowed to remain there about 25 minutes, the casing (and tube) being turned round about its axis from time to time.

It was impossible to obtain tubes of exactly uniform thickness of wall. In a long length of tube the thickness would be practically uniform at one section, while at another section there might be a considerable variation. The maximum variation in thickness of wall of the tubes used in the tests was 0.007in., means being taken (see description of apparatus for compression tests) to obtain uniformity of compressive stress. The ends of all the tubes tested were accurately faced up in the lathe.

Apparatus for tension.—After several failures to hold the ends of

FIG. 4.

Diagram of Frame used with Ewing Extensometer.



the tubes, the following plan was adopted:—A holder, A A, Fig. 1, was made for each end of the tube, the larger end of the holder being turned to fit the 3in. bore tube, and the smaller end screwed to fit ball-and-socket holders of the testing machine. The outer end of the 3in. diameter part was slightly bevelled off, while the inner end had a turned cavity to accommodate a cup leather C. A pipe flange B was fitted round each end of the tube, and the slightly projecting ends D of the tube were riveted down into the small conical bevelling on A A. Another pipe flange of bore about 3in. (not shown in the Fig.) was placed face to face with B, and fixed to it with set screws. This second flange kept B in position during the straining of the tube. The tube always broke at some distance away from the holders. The cup leathers C made the interior water-tight for the tests in which water pressure was used to give hoop tension. A hole through the centre of A A allowed the introduction of hydraulic pressure.

Apparatus for compression.—Fig. 2 shows the pedestal on which

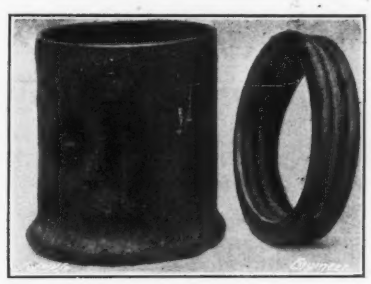


Fig. 5

the tube to be compressed rests. Water under pressure could be supplied from the tube shown through a passage in the centre of the pedestal. The conical piece to the left in Fig. 2 is a cap for the top of the tube. This cap was turned so that the axis of the cone was perpendicular to the circular base of the cone, and concentric with it. The cone was placed truly upon the top of the tube so that the axis of the tube and cone were coincident.

When, however, the thickness of the walls of the tube was not quite uniform over the circumference, and where, accordingly, the centre of gravity of the ring cross section deviated measurably from the axis of the tube, the cone was placed, by means of a template, in such position that its axis passed through this centre of gravity. By this means an equal distribution of compressive stress was brought on the tube. The greatest eccentricity in the position of the cap to compensate for the variation of thickness was 0.04in.

Apparatus for shear tests.—As before mentioned, the shear was obtained by equal axial compression and hoop tension. The tube to be tested was set up exactly as for compression; and in many cases the tests for yield-point in compression and shear were made on the same tube thus fixed up. Where the thickness of the walls of the tubes was not quite uniform the calculation of the hoop

Fig. 6

tension was made for the minimum thickness. The joints between the pedestal and tube, and between the cap and tube, were made with thin sheet lead.

Apparatus for simultaneous axial and hoop compression.—The difficulty of making reliable tests under these conditions arises from the fact that a jacket exterior to the tube must contain fluid under pressure, and must at the same time be so flexible that it will not impede the elastic or other shortening of the tube under test. In other words, the axial compressive stress on the tube must be calculable as well as the hoop stress. The jacket designed by the author is shown in Fig. 3. It was cast in two exactly similar halves A and B. The exterior cylindrical turned part of each fitted loosely into a ring C, the whole of which was machined except the exterior cylindrical surface. The joint between A and C and between B and C was made by a hollow india-rubber ring R, placed between A and B as a cushion and fitted into C. Water was admitted to the external jacket thus formed through the tube shown. Holes drilled in the inner wall of the rubber ring admitted water to its interior. The piece of tube D (about 4in. long) to be tested is shown in position inside A. The joints between A and B and the tube were made with thin lead rings.

It required about 0.20 ton to compress the rubber ring (when under test) to the working position. The apparatus was calibrated by plugging the holes in the flat ends of A and B, introducing

Fig. 7

water at known pressures to the whole of the interior of the cavity, and placing the apparatus in the testing machine. The whole load on either half, A or B, is thus known, and also the water pressure; from these the effective area of A and B subjected to pressure may be calculated. When a tube was under test the compressive load on the tube was therefore the load on the testing machine less the effective area of A or B (diminished by the exterior area of the tube) multiplied by the pressure in the jacket. The rods labelled E and F, Fig. 3, have no connection with each other, but each is connected to the tube by three hard steel-pointed screws set in the same horizontal plane. E and F therefore indicated the behaviour

Fig. 8

of the piece of tube between the two planes of the points, a length of about 1½in. in the tests made. A Ewing compressometer was attached by its own screws to E and F, and measured the relative vertical movement of E and F, and therefore the change of length of the tube between the horizontal planes of the points.

Measurement of the strains.—The axial strains were those measured. Except in the case of simultaneous axial and hoop compression, a Ewing extensometer was used. This instrument measures diminution or increase of length equally well, and the one employed could be read to $\frac{1}{10000}$ of an inch. The length on which the strain was measured was in some cases 10in. and in the others 5in. As the instrument would not take a specimen of so

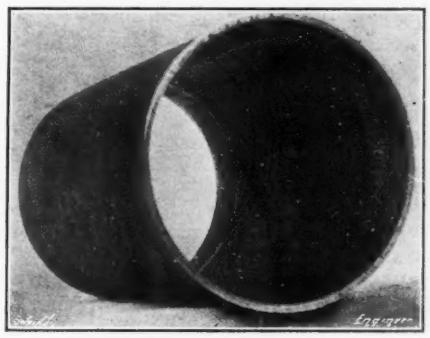


Fig. 9

large diameter as 3in., a frame shown diagrammatically in Fig. 4 was made. It consisted of two equal bars b_1 b_2 each bent into a U-shape. The ends of the U-shaped pieces were bolted to thinner strips s s, while at the centre of each bend there was bolted a short length of inch diameter bar r r. Steel screws p p, with hardened points, fastened the frame to the tube under test in such a manner that the planes of the U's were horizontal and the strips s s vertical. The latter acted as hinges when the points p p moved slightly owing to the strain of the tube. The extensometer was secured by its own screws to the short bars r r.

In the simultaneous axial and hoop compression tests, the (axial)

* The Institution of Mechanical Engineers.

† Professor E. L. Hancock, *Philosophical Magazine*, February and October, 1906; Mr. W. A. Scoble, *Philosophical Magazine*, December, 1906, and "Proceedings" of the Physical Society, September, 1907.

length on which it was attempted to measure the strain was about 1¼in. It was found, however, that the readings of the compressometer were affected by some elastic distortion of the apparatus connecting the compressometer with the tube. The readings, and the curves plotted therefrom, show the yielding of the specimens, but cannot be used to calculate the elastic constants.

Calibration of the pressure gauge.—The pressure gauge used was of the Bourdon pattern. It was tested against a standard gauge reading to 400 lb. per square inch, which was calibrated by dead weights. It was also tested, for higher pressures, against two standard Bourdon gauges. Also, verification within 2 per cent. was obtained by testing the gauge against the apparatus used for simultaneous axial and hoop compression.

Testing machine.—The testing machine in which the tests were made was the 100-ton Buckton machine in the Walker Engineering Laboratory of the University of Liverpool.

Stress in two dimensions.—In all work hitherto done (so far as the author knows) upon strength under combined stress, and in this work also, the stress has been two dimensional, one set of parallel planes being left entirely, or very nearly, unstressed. Such a condition is always equivalent to that due to two "principal stresses"—that is, to such a state as that of a rectangular plate which is pulled or compressed longitudinally, and simultaneously pulled or compressed in the direction of the breadth, the stresses

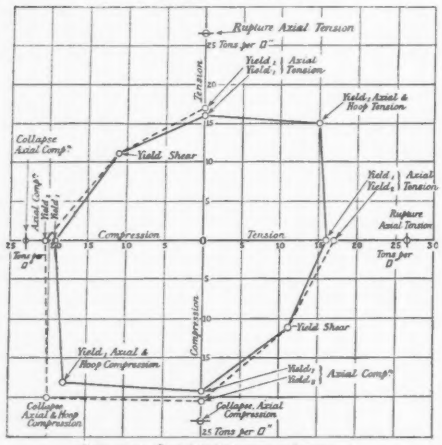
Fig. 10

being both tensions or both compressions, or one being tension and the other compression. If p_1 and p_2 are not equal, shear stress will exist on all planes except those parallel to the faces and the edge planes of the plate. The maximum shear stress will occur thus:—

Conditions.	Planes on which greatest shear stress occurs.	Maximum shear stress.
p_1 and p_2 Both tensile or both compressive. $p_1 > p_2$	Planes parallel to p_2 and at 45° to p_1	$\frac{1}{2}\ p_1$
$p_2 > p_1$	Planes parallel to p_1 and at 45° to p_2	$\frac{1}{2}\ p_2$
$p_2 = 0$	Planes at 45° to p_1	$\frac{1}{2}\ p_1$
$p_1 = 0$	Planes at 45° to p_2	$\frac{1}{2}\ p_2$
$p_2 = p_1$	Planes at 45° to p_1 and parallel to p_2 Planes at 45° to p_2 and parallel to p_1	$\frac{1}{2}\ p_1 = \frac{1}{2}\ p_2$
and p_2 of opposite sign (one of them compressive and the other tensile).	Planes at 45° to each of the planes on which p_1 and p_2 act Note— When $p_1 = p_2$ there is no normal component of stress on these planes at 45°, *i.e.*, there is pure shear stress on these planes	$-\frac{1}{2}\ (p_1 + p_2)$

It will be observed that in the experiments carried out by the

Fig. 11.
Diagram showing Strength of Tube, Not Annealed.
(*See* Table 5.)
Tube 3-inch bore. 0·082-inch thick.



Yield, denotes "Yield Point" determined by Extensometer
Yield, " " " observed not using "

author, p_1 corresponds with the axial tension or compression, and p_2 with the hoop tension or compression. In the simultaneous axial compression and hoop tension tests the planes of greatest shear at any point of the tube wall are two planes intersecting on the radius of the tube through the point, at right angles to each other and at 45 deg. to the axis of the tube.

In the simple compression tests, the planes of greatest shear are any planes cutting the axis of the tube at 45 deg. Thus certain planes of this set are the same as the planes of greatest shear in the simultaneous compression and hoop tension tests. But the latter may not be the planes of least resistance to shear stress if the material is not isotropic; certain of the former set may be weaker under shear. If so, the tube may yield under a less shear stress, induced by simple compression, than the shear stress produced—on other planes—by simultaneous compression and hoop tension even if the theory of yield by shear is true. In other words, if the material is not isotropic, but the condition for yielding is simply the existence of a shear stress of specific intensity, the $\frac{1}{2}\ p_1$ cannot be greater than and will probably be less than

$$\frac{1}{2}\ (p'_1 + p_2)$$

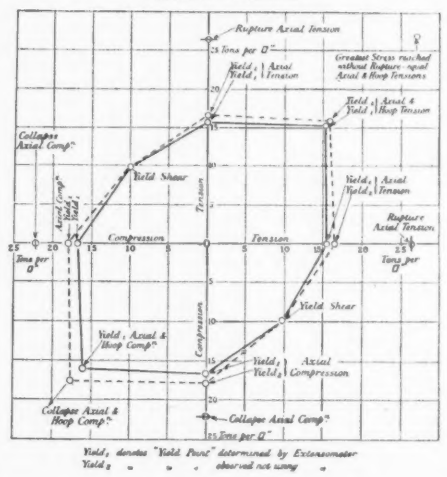
where p_1 = yield stress in simple compression.
p'_1 = axial compression stress } at yield under
p_2 = hoop tensile stress } simultaneous stresses.

If the material is isotropic, and if it yields when the shear stress induced anywhere exceeds this specific value—whether there is or is not normal stress on the planes of this shear—we shall expect to find that

$$\frac{1}{2}\ p_1 = \frac{1}{2}\ (p'_1 + p_2).$$

The tests.—It will be seen from the Tables II., III., IV., V. in the Appendix of the results of the tests that the specimens are divided into groups. All those in a group were cut from the same length of tubing. The specimens in each group are numbered; where there are two or more with the same numeral but distinguished by "a," "b," the tube has undergone the first test or tests "a," and afterwards a piece has been cut out from it, faced up in the lathe,

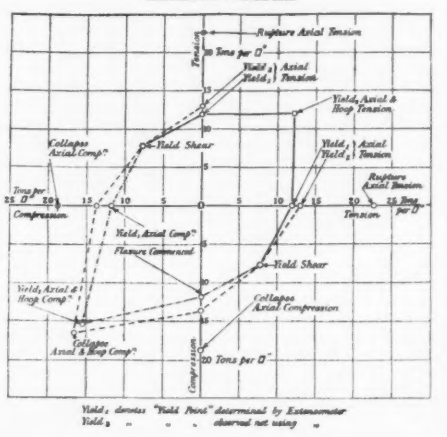
Fig. 12
Diagram showing Strength of Tube, Not Annealed
(*See* Table 5.)
Tube 3-inch bore. 0·082-inch thick.



Yield, denotes "Yield Point" determined by Extensometer
Yield, " " " observed not using "

and subjected to the further test or tests "b." Specimens that were annealed together are shown bracketed. In general more than one test was done on the same specimen; but throughout the work when making a test on a specimen on which further yield-point experiment was to be done, the loading was discontinued when the extensometer showed a definite yield-point or a definite yielding of the test-piece. The fifteen curves, also shown in the Appendix, show how far such stressing was carried. The

Fig. 13.
Diagram showing Strength of Tube, Annealed.
(*See* Table 5.)
Tube 3-inch bore. 0·076-inch thick.



Yield, denotes "Yield Point" determined by Extensometer
Yield, " " " observed not using "

order of the figures in the columns of the tables corresponds to that in which the tests on a specimen were done.

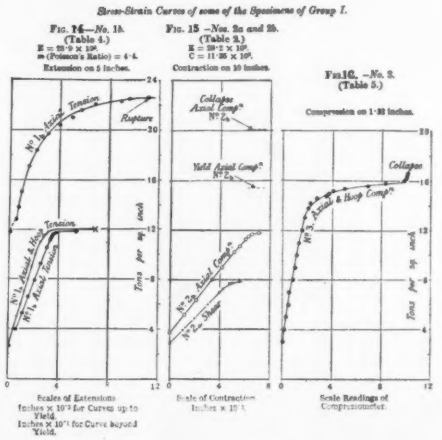
The actual yield-loads and pressures have not been tabulated, nor the dimensions of the cross-sections of the tubes. Each specimen tested was accurately callipered by a micrometer-gauge. The sectional areas of almost all specimens cut from the same tube were sensibly the same, though the maximum and minimum thicknesses varied slightly. A list was made out for use in all the tests

Stress-Strain Curves of some of the Specimens of Group I.

Fig. 14.—No. 1b. (Table 4.) E = 29·9 × 10⁶. m (Poisson's Ratio) = 4·4. Extension on 5 inches.

Fig. 15.—Nos. 2a and 2b. (Table 4.) E = 29·2 × 10⁶. C = 11·26 × 10⁶. Contraction on 10 inches.

Fig. 16.—No. 3. (Table 5.) Compression on 1·32 inches.


No. 1b. Axial Tension
Rupture
Tension
No. 1a. Axial & Hoop Tension
No. 1c. Axial Tension
Tons per sq. inch
Collapse Axial Comp? No. 2a
Yield Axial Comp? No. 2a
No. 2a. Axial Comp?
No. 2c. Shear
No. 3. Axial & Hoop Comp?
Collapse
Scales of Extensions Inches × 10⁻³ for Curves up to Yield. Inches × 10⁻⁴ for Curve beyond Yield.
Scale of Contraction Inches × 10⁻⁴.
Scale Readings of Compressometer.

of a group in which hydraulic pressure was employed, the list giving the loads on the testing machine and the corresponding pressures on the gauge, so that the required proportion between compressive and hoop stress—usually equal—might be maintained constant throughout a test. The hoop stress varied, of course, from a maximum at the inside skin of the tube to a minimum at the outside. This variation was about 5 per cent. for the 14-G, and about 9½ per cent. for the 10-G tubes. The maximum stress is the one adopted for calculation. Of course, the loads on the testing machine were corrected for the upward thrust of the water pressure, and the pressure-gauge readings rectified according to the curve of calibration of the gauge. Small corrections, appropriate to the callipered dimensions of the tube, were afterwards applied to the yield-stress as indicated on the list mentioned above.

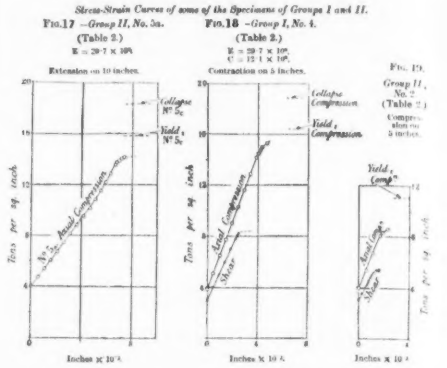
Tests in compression (Tables II. and III.).—It was necessary to ascertain whether the thinness of the tube walls caused premature yielding. Preliminary experiments on the tube in tension gave a yield-point stress rather less than the stress at which yield occurred in short specimens in compression. On the greater number of the specimens cut from the tube of 14-gauge wall thickness, the extensometer showed apparent yielding in compression—due to flexure—at a stress Y_1 considerably below the stress Y_2 at which the first indication of yielding could be detected by a pair of compasses applied to shorter specimens. But certain tests, for example, No. 4, Group I.—Fig. 18; No. 6A, Group V.—Fig. 22; and No. 1,

Stress-Strain Curves of some of the Specimens of Groups I and II.

Fig. 17.—Group II, No. 3a. (Table 2.) E = 29·7 × 10⁶.

Fig. 18.—Group I, No. 4. (Table 2.) E = 29·7 × 10⁶. C = 12·1 × 10⁶.

Fig. 19. Group II., No. 2. (Table 2.)

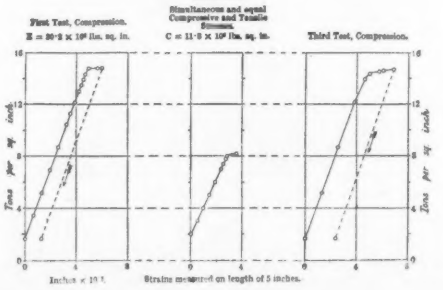


Group VI.—Fig 25—showed only about the same difference between Y_1 and Y_2 as between similarly observed yield stresses on the tube in tension. The yielding of short specimens, and of those just mentioned, was simultaneous with the commencement of disturbance or peeling of the scale, and many of these showed signs of flexure of the wave kind. Some of the specimens on which the Y_1 had been observed showed slight disturbance of the walls. The stresses Y_1 and Y_2 are both tabulated; but when it was obvious that the yielding occurred by flexure before the yield point of the metal was reached, the corresponding value of Y_1 was left out of the calculations. Neglecting such values, it is certain that the Y_1 stresses were rather below the yield point, while it is probable, from the behaviour and appearance after test of the specimens, that the Y_2 stresses were not less than the true yield stresses of the material in compression.

On all the specimens of the tube of 10-gauge wall thickness the extensometer showed a very definite yielding, which was always simultaneous with the appearance of "Lüder's lines" on the surface. The stresses at this point are entered in the tables in a column headed $Y_1 = Y_2$, and are believed by the author to be those at the exact yield or very closely approximate to the true yield point in compression. It is possible that elastic flexure of the walls of the tubes may have commenced even in the early stages of the tests. If so, the effect was so small that it was not detected. A simple calculation shows that no measurable increase due to this cause in the elastic contraction in the length of the tube was to be expected. The value of Young's modulus calculated from the compression tests came out quite normal, these values ranging from 28.2×10^6 to 30.2×10^6 lb. per square inch. In some cases the stresses at collapse of the tubes are given in the tables for the purpose of comparison with the yield stresses. Collapse always occurred by wave-like flexure of the walls of the tubes—see Fig. 5. The collapse load on the machine was sufficient to compress a tube into the form shown on the right in Fig. 5.

Tests in simultaneous compression and hoop tension (Tables II. and III.).—The tests in simultaneous axial compression and hoop tension always gave very definite results. The method of testing was to so regulate the load and the internal water pressure that the ratio—unity in most cases—of axial compressive to hoop tensile stress was constant throughout a test. In all cases, whether the specimens were or were not annealed, the yield point was perfectly definite. The curves plotted from these tests show a very quick bend from the straight line portion of the stress-strain curve. Moreover, specimens cut from the same tube, similarly annealed or not annealed, gave very uniform values of the yield stress. Interesting markings—"Lüder's lines"—always became visible on the specimens at the yield point, due to the disturbance of the scale on the tube as the metal yielded. Figs. 6 to 9 show these markings. These lines or bands were in parallel spirals, there being two systems of these equally inclined to the generators of the tube surface and inclined at about 88 deg. to each other. They very nearly corresponded with the planes of maximum shear. Sometimes the lines appeared on the outside of the tubes, the time of their appearance exactly coinciding with the first indication of the yield on the extensometer, or when this point had been exceeded by not more than 0.20 ton per square inch of shear stress. When the lines did not appear on the outside

Fig. 20.
Stress-Strain Curves of Group III, No. 5. (Table 2.)
Thickness of Wall 0·127 inch. Length 9 inches. Annealed.


Second Test.
First Test, Compression.
E = 30·2 × 10⁶ lbs. sq. in.
Simultaneous and equal Compressive and Tensile Stresses.
C = 11·3 × 10⁶ lbs. sq. in.
Third Test, Compression.
Tons per sq. inch
Inches × 10⁻³.
Strains measured on length of 5 inches.

they were always to be seen on the inside when examination was made after test. Photographs—Figs. 7 and 8—are of the same tube, and show the markings on the inside and outside respectively. Several of the lines are exactly opposite to each other on the sides of the tube wall—that is, are in the same spiral surface.

One or two experiments were made on both annealed and unannealed tubes to ascertain whether the direction of these lines would be altered by the presence of a normal compressive or of a normal tensile component on the planes of greatest shear. The compressive axial stress was made respectively twice, and one half, the hoop tensile stress, but the change, if any, in the angles of the lines was very small. Some tubes which had been strained to the shear yield point showed no buckling or disturbance of the

alls, while others did show some slight effect of this sort. Short tubes gave practically the same yield point stress as long tubes. Table I. gives the results of six tests upon specimens of different lenghts:—

TABLE I.

Length.	Stress at appearance of lines.	Remarks.
In		
0.9	12.37	Cut from same tube.
4	12.33	
1	12.87	
3	11.05	Cut from same tube.
6	11.25	
18.7	11.10	

No difference in direction or angles of the markings could be detected whether the tubes were long or short. It was expected that the frictional gripping of the ends against the pedestal and

Stress-Strain Curves of some of the Specimens of Group V.

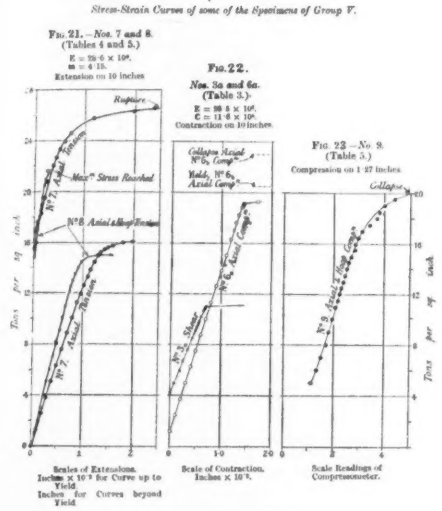


FIG. 21.—Nos. 7 and 8. (Tables 4 and 5.)
E = 29·6 × 10⁶.
m = 4·15.
Extension on 10 inches
Rupture
Max^m Stress Reached
N°7 Axial Tension
N°8 Axial Tension
FIG. 22.
Nos. 3a and 6a. (Table 3.)
E = 30·6 × 10⁶.
C = 11·6 × 10⁶.
Contraction on 10 inches.
Collapse Hoop
N°3, Comp^n
Yield, N°6, Axial Comp^n
N°3, Shear
N°6, Axial Comp^n
FIG. 23.—No. 9. (Table 5.)
Compression on 1·27 inches.
Collapse
N°9, Axial & Hoop Comp^n
Tons per sq. inch.
Scale of Extensions. Inches × 10⁻³ for Curve up to Yield. Inches for Curves beyond Yield.
Scale of Contraction. Inches × 10⁻³.
Scale Readings of Compressometer.

cap would somewhat relieve a tube of the water pressure load near its ends. The above table shows that there can be little such effect. The presence of the lead rings forming the water-tight joint, though squeezed extremely thin, may perhaps be the explanation.

Results of compression tests compared with results of tests in simultaneous axial compression and hoop tension.—Tables II. and III. The maximum shear stress in a specimen in simple compression being one-half of the compressive stress, one-half of the compressive stress at yield has been subtracted from the shear stress S at yield, induced in the specimen by simple compression and hoop tension of equal amounts. This difference, and also this difference divided by S and multiplied by 100, giving the percentage variation, are given in the Tables II. and III. It will be seen for the 14-G tubes that $S - \frac{1}{2} Y_1$ is always positive, while $S - \frac{1}{2} Y_2$ is sometimes positive and sometimes negative; while for the 10-G tubes $S = \frac{1}{2} Y$ is always positive. Over the whole range of annealed tubes the percentage variation ranges from + 11.3 to − 9.3; on the 10-G tubes above the range is from + 10.2 to + 22. The arithmetic mean of the whole of these percentages is + 2.8 per cent.

In Table III., which sets forth the results on tubes in the condition as received from the maker, and without further annealing, $S - \frac{1}{2} Y$ is always positive, and the percentage variation ranges from 20.2 to 8.7. An apparent explanation of the larger differences is that the material was weaker in shear on some other planes than

Stress-Strain Curves of some of the Specimens of Group VI.

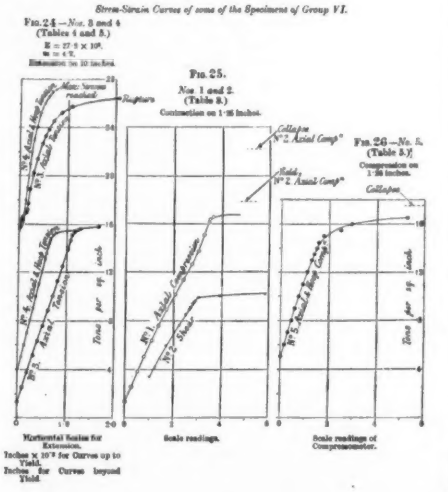


FIG. 24.—Nos. 3 and 4 (Tables 4 and 5.)
E = 27·5 × 10⁶.
m = 4·7.
Extension on 10 inches.
FIG. 25.
Nos. 1 and 2. (Table 3.)
Contraction on 1·26 inches.
FIG. 26.—No. 5. (Table 5.)
Compression on 1·26 inches.
Rupture
Max^m Stress reached
N°4 Axial Tension
N°3 Axial Tension
Collapse N°2 Axial Comp^n
Yield N°2 Axial Comp^n
N°1 Axial Compression
N°2 Shear
N°5 Axial & Hoop Comp^n
Collapse
Tons per sq. inch.
Horizontal Scale for Extension. Inches × 10⁻³ for Curves up to Yield. Inches for Curves beyond Yield.
Scale readings.
Scale readings of Compressometer.

those on which the pure shear—due to equal axial compressive and hoop tensile stress—fell.

A circumstance that must be mentioned was the existence of a third principal stress, of small amount, in the tests in simultaneous axial and hoop stress, namely, the compressive stress due to the water pressure. This stress varies from an amount equal to the water pressure at the inner surface of the tube to nothing at the outer surface. The hydraulic pressure—and therefore the maximum value of the stress—was, in the case of the 14-G tubes, about 5 per cent., and of the 10-G tubes about 8½ per cent., of the hoop tensile stress.

Tensile tests.—Tables IV. and V. In Table IV. will be found the results of the few tensile tests made, and also comparisons of these with the compression and shear tests. Few tensile tests were made, because the main object of the writer was to obtain checks on other results. It will be seen from Table V. that three tests were made in simultaneous axial and hoop tension of equal amounts, and that the yield stress was practically the same as in simple tension. This is in agreement with the theory that yield occurs by shearing independent of a normal stress. The yield stresses in simple tension and in simple compression do not agree

APPENDIX.

TABLE II.—*Annealed Mild Steel Tubes.*

Comparison of maximum shear stress at yield under simultaneous axial compression and hoop tension with maximum shear stress at yield under simple axial compression. Stresses in tons per square inch.

Size.	Group.	No. of specimen.	Length.	Simultaneous axial compression and hoop tension: Compressive stress.	Simultaneous axial compression and hoop tension: Tensile stress.	Simultaneous axial compression and hoop tension: Maximum shear stress, S.	Simple axial compression: Stress at yielding. Y_1.	Simple axial compression: Stress at yielding. Y_2.	Simple axial compression: Maximum shear stress at yield point. $= \frac{1}{2} Y_1$.	Simple axial compression: Maximum shear stress at yield point. $= \frac{1}{2} Y_2$.	Simple axial compression: Stress at collapse.	$S - \frac{1}{2} Y_1$.	$S = \frac{1}{2} Y_2$.	$\frac{S - \frac{1}{2} Y_1}{S} \times 100$.	$\frac{S - \frac{1}{2} Y_2}{S} \times 100$.
			in.												
3in. bore, 14 gauge (about 0·08in.)	I.	1a	3	7.73	7·63	7.68	—	13.72	—	6.86	18.8	—	0·82	—	10.7
		2a	18	8.20	8.10	8.15	†11.30	—	—	—	—	—	0.40	—	4.9
		2b	4	—	—	—	†11.80	15.50	—	7.75	20.1				
		*4	7	8.45	8.38	8.41	—	—	—	—	—				
		5	7	8.30	8.05	.17	15.40	16.35	7.70	8.18	18.9	0.71	0.23	8.4	2.7
	II.	1	7	6.85	7.00	6.93	14.50	—	7.25	—	—	0.92	—	11.3	—
		*2	10¼	5.38	5.28	5.33	—	15.00	—	7.50	—	—	-0.57	—	-8.2
		3	15	6.78	6.74	6.75	†8.66	—	—	—	—	—	-0.19	—	-3.5
		4a	19	5.64	5.56	5.60	†8.56	11.05	—	5.52	—				
		4b	4	—	—	—	12.5	—	6.25	—	—	0.51	—	7.5	—
		*5a	24½	—	—	—	†9.1	—	—	—	—				
		5b	7	7.08	7.42	7.25	—	12.25	—	6.12	18.95	—	-0.52	—	-9 3
		5c	3	—	—	—	14.02	—	7.01	—	—				
		*6	4½	6.30	6.22	6.26	—	15.80	—	7.90	19.30	0.24	-0.65	3.3	9.0
		7	4	—	—	—	—	11.05	—	—	16.25				
		8	7½	8.80	4.40	6.60 Mean = 6·22	—	— Mean	—	6.15	—	—	0.07	—	1.1
		9	7¼	3.80	7.80	5.80	—	13.60 =12.3	—	—	—				
	IIa.	1a	18	5.28	4.85	5.06	†7.70	—	—	—	—				
		1b	4	—	—	—	†7.82	—	—	—	—	—	-0.46	—	-9.1
								11.05	—	5.52	17.55				
2¾in. bore, 10 gauge (about 0·127in.)	III.	1	14	8.43	8.52	8.47	$Y_1 = Y_2$.		$\frac{1}{2} Y_1 = \frac{1}{2} Y_2$.						
		2	9	8.26	8.70	8.28		16.10		8.05	—		0.42		5.0
		3	4½	8.58	8.60	8.59		16.20		8.10	—		0.18		2.2
		4	4½	9.05	9.12	9.08		15.60		7.80	—		0.79		9.2
		*5	9	8.12	8.20	8.16		16.30		8.15	24.80		0.93		10.2
		6	9	8.28	8.53	8.40		14.78		7.39	—		0.77		9.4
		7	9	10.41	5.86	8.13 Mean		14.40		—	—				
				8.55	8.60	8.57 =8.35		15.83		7.91	—		0.49		5.8
		8	8	11.74	4.81	8.27		16.10		8.05	—				
		9	8	8.05	8.38	8.21		—		—	—		0.30		3.6
				11.50	3.82	7.66		—		—	—		—		—

* Curves are given for these specimens, Figs. 15, 17, 18, 19, and 20. † Flexure commenced (not yield point).

TABLE III.—*Mild Steel Tubes (not Annealed).*

Comparison of maximum shear stress at yield under simultaneous axial compression and hoop tension with maximum shear stress at yield under simple axial compression. Stresses in tons per square inch.

Size.	Group.	No. of specimen.	Length.	Simultaneous axial compression and hoop tension: Compressive stress.	Simultaneous axial compression and hoop tension: Tensile stress.	Simultaneous axial compression and hoop tension: Maximum shear stress, S.	Simple axial compression: Stress at yielding. Y_1.	Simple axial compression: Stress at yielding. Y_2.	Simple axial compression: Maximum shear stress at yield point. $= \frac{1}{2} Y_1$	Simple axial compression: Maximum shear stress at yield point. $= \frac{1}{2} Y_2$.	Simple axial compression: Stress at collapse.	$S - \frac{1}{2} Y_1$.	$S - \frac{1}{2} Y_2$.	$\frac{S - \frac{1}{2} Y_1}{S} \times 100$.	$\frac{S - \frac{1}{2} Y_2}{S} \times 100$.
			in.												
3in. bore, 14 gauge (0.08in.)	IV.	1	3	10.6	10.6	10.6 Mean	—	—	—	—	—				
		2	4	10.7	10.7	10.7 =10.53	—	—	—	—	—				
		3a	15	10.3	10.3	10.3	—	—	—	—	—				
		3b	4	—	—	—	—	19.1 Mean	—	9.55 Mean	23.0				
		4	2	—	—	—	—	17.3 =17.72	—	8.65 = 8.86	22.8	—	1.67	—	15.9
		5	3	—	—	—	—	16.75	—	8.37	22.0				
	V.	1	3	11.05	11.05	11.05 Mean	—	—	—	—	—				
		2	6	11.25	11.25	11.25 =11.13	—	—	—	—	—				
		*3a	19	11.10	11.10	11.10	—	—	—	—	—				
		3b	4	—	—	—	—	20.5	—	10.25	—				
		4	4	—	—	—	†14.7	— Mean	—	— Mean	22.1	1.51	1.08	13.6	9.7
		5	4	—	—	—	†16.1	— =20·5	—	— =10.25	—				
		*6a	19	—	—	—	19.25	—	9.62	—	23.0				
		6b	4	—	—	—	—	20.5	—	10.25					
	VI.	*1	5½	—	—	—	15.7	—	8.35	—	—				
		*2	6	9.8	9.8	9.80	—	17.9	—	8.95	22.0	1.45	0.85	14.8	8.7
	VII.	1	7	12.7	12.7	12.70 Mean	—	—	—	—	—				
		2	7	12.6	12.6	12.60 =12.65	—	21.8 Mean	—	10.09 Mean	—	—	1.40	—	11.1
				—	—	—	—	23.2 = 22.5	—	11.6 =11.25	—				
2¾in. bore, 10 gauge (0.128in.)	VIII.						$Y_1 = Y_2$		$\frac{1}{2} Y_1 = \frac{1}{2} Y_2$						
		1	9	10.25	10.28	10.26		16.38		8.19	—		2.07		20.2
		2	9	9.80	9.70	9.75		16.00		—	—				
								16.10		8.05	—		1.70		17.5

* Curves are given for these specimens, Figs. 22 and 25. † Flexure commenced, not yield stress.

TABLE IV.—*Results of Tests in Axial Tension and in Axial Compression Compared with Results of Tests in Simultaneous Axial Compression and Hoop Tension.*

Stress in tons per square inch.

Size of tube.	Group.	No. of tube.	Length.	Data from tests: Compression. Yield stress. Y_1.	Compression. Yield stress. Y_2.	Compression. Stress at collapse.	Simultaneous and equal axial compression and hoop tension. Maximum shear stress = S.	Tension. Yield stress. Y_1^1.	Tension. Yield stress. Y_2^1.	Tension. Stress at rupture.	Maximum shear at $Y_1 = \frac{1}{2} Y_1$.	Maximum shear at $Y_2 = \frac{1}{2} Y_2$.	$\frac{S - \frac{1}{2} Y_1}{S} \times 100$.	$\frac{S - \frac{1}{2} Y_2}{S} \times 100$.	Maximum shear at $Y_1^1 = \frac{1}{2} Y_1^1$.	Maximum shear at $Y_2^1 = \frac{1}{2} Y_2^1$.	$\frac{S - \frac{1}{2} Y_1^1}{S} \times 100$.	$\frac{S - \frac{1}{2} Y_2^1}{S} \times 100$.	Remarks.
			in.																
2in. bore, 14 gauge (about 0.08in.	I.	1a	3	—	13.72	18.2	7.60	—	—	—	—	6.86	—	—	—	—	—	—	Cut from same annealed tube
		*1b	20	—	—	—	—	11·85	12.85	22.6	—	—	—	—	5.93	6.42	22.0	15.5	
	IV.	3a	15	—	—	—	10.31	—	—	—	—	—	—	—	—	—	—	—	Cut from same tube. Not annealed
		3b	4	—	19.1	23.0	—	—	—	—	—	9.55	—	—	7.4	—	—	—	
		6	20	—	—	—	—	—	17.3	25.8	—	—	—	—	—	8.65	—	16.1	
	V.	*6a	19	19.25	—	—	11.13	—	—	—	9.62	—	13.6	—	—	—	—	—	Do. Do.
		6b	4	—	20.5	23.0	—	—	—	—	—	10.25	—	—	7.9	—	—	—	
		*7	21	—	—	—	—	16.0	17.0	26.6	—	—	—	—	8.00	8.50	28.1	23.6	
	VI.	*1	5½	16·7	—	—	—	—	—	—	8.35	—	14.6	—	—	—	—	—	Do. Do.
		*2	6	—	17.9	22.2	9.78	—	—	—	—	8.95	—	—	8.5	—	—	—	
		*3	21	—	—	—	—	15.7	16.6	26.47	—	—	—	—	7.85	8.30	19.7	15.1	

* Curves are given for these specimens, Figs. 14, 21, 22, 24, and 25.

well, especially—as might perhaps be expected—for the tubes tested without further annealing, the yield stress in compression being considerably higher than the corresponding ones in tension.

The percentage difference $\left(\frac{S - \frac{1}{2}Y_2}{S} \times 100\right)$ varies from 15 to 23½ per cent. Two similar specimens, one tested in simple tension and the other in simple compression, are stressed equally and similarly on all corresponding plans, except that the stresses in the one case are in the reverse direction to those in the other case. Hence, if the resistance to shearing is independent of the sign of the normal stress, the yield stresses should be equal in magnitude in the two cases.* But three of the tubes tested in tension were not annealed, and it may be that the resistance to shear of the metal was not merely different in various directions, but was also not the same on any one plane against stresses of opposite sign.

Tests given in Table V.—Figs. 11, 12 and 13. So far as the author is aware no series of tests such as given in Table V. have been made previously.

All the tests in a set were on specimens cut from the same piece of tubing; those of one of the sets being annealed together. Where possible the tests were carried up to rupture or collapse of the material. The tests in equal axial and hoop tension could not be carried to rupture on account of leakage of water past the cup-leathers, which ceased to act owing to the increase of diameter of the tubes. The tests in equal axial and hoop compression show almost as high values for the yield and collapse loads as in simple compression. This might possibly be due to the lateral support of the tube by the frictional gripping of the ends, but it may be remarked that there appeared to be little such support afforded to the specimens in compression and internal water pressure—see Table I. Fig. 10 shows a tube which has been tested to collapse in equal hoop and axial compression.

Conclusion.—The experiments show an approximate agreement between the maximum shear stress at the yield point in compression and the yield-point stress in pure shear, the mean difference in the tests of annealed specimens being about 3 per cent. It appears, then, that mild steel in direct compression yields by shearing; and, to a first approximation that the value of this shear stress is independent of any normal compressive stress on the planes of the slide.

The author is much indebted to Professor W. H. Watkinson for affording facilities for carrying out the research in the Walker Engineering Laboratory of the University of Liverpool, and for encouragement in the prosecution of it. Also he wishes to thank those students, especially Messrs. J. R. Beaumont, A. Vas Gomes, H. J. F. Gourley, C. H. Jennings, H. A. T. Smith, and G. E Pym, who very efficiently helped him to make the apparatus and carry out the tests. He is also much indebted to Mr. W. Donaldson, the Chief Instructor in the Laboratory, for his assistance and valuable suggestions.

TABLE V.—*Results of Tests in Tension, Compression, and Combined Stress, which are Plotted in Diagrams Figs.* 11, 12, *and* 13.

Stresses in tons per square inch.

Size of tube.	Group.	No. of tube.	Length.	Axial tension. Yield stress. Y_1.	Axial tension. Yield stress. Y_2.	Axial tension. Stress at rupture.	Axial tension = hoop tension. Yield stress. Y_1.	Axial tension = hoop tension. Yield stress. Y_2.	Axial tension = hoop tension. Maximum stress attained.	Shear. Axial Compression = hoop tension.	Axial compression. Yield stress. Y_1.	Axial compression. Yield stress. Y_2.	Axial compression. Stress at collapse.	Axial compression = hoop tension. Stress. Yield Y_1.	Axial compression = hoop tension. Stress. Collapse.	Remarks.
3in. bore, 14 gauge (0.08in.)	V.	*6a	19	—	—	—	—	—	—	—	19.25	—	—	—	—	
		6b	4	—	—	—	—	—	—	11.13	—	20.5	25.0	—	—	Cut from same piece of tube. Not annealed
		*7	21	16.0	17.0	26.6	—	—	—		—			—	—	
		*8	21	—	—	—	15.0	—	21.0		—	—	—	—	—	
		*9	4	—	—	—	—	—	—		—	—	—	18.0	20.0	
	VI.	*1	5½	—	—	—	—	—	—	—	16.7	—	—	—	—	
		*2	6	—	—	—	—	—	—	9.78	—	17.9	22.2	—	—	Cut from same piece of tube. Not annealed
		*3	21	15.7	16.6	26.47	—	—	—		—	—	—	—	—	
		*4	21	—	—	—	15.4	15.8	27.0		—	—	—	—	—	
		*5	4	—	—	—	—	—	—		—	—	—	16·0	17.5	
	I.	1a	3	—	—	—	—	—	—	7.60	—	13.72	18.8	—	—	Cut from same piece of tube. Annealed
		*1b	21	11.85	12.83	22.6	12.0	—	—		—	—	—	—	—	
		*3	4	—	—	—	—	—	—		—	—	—	15.5	16.60	

* Curves are given for these specimens, Figs. 14, 16, 21, 22, 23, 24, 25, and 26.

* The Report of the Steel Committee of Civil Engineers, 1910, shows very close agreement between the yield stress in tension and compression of steel and wrought iron bars. Mr. L. B. Turner has recently published some tests on annealed tubing in simple pull and simple torque. The mean difference of the shear stress at yield point between the two kinds of tests is about 3 per cent.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

FERRY STEAMERS.

Sir,—We notice in last week's Engineer, page 645, an illustration and descriptive matter of the double-ended ferry steamer Guanabacoa, and it is there stated that she is the first vessel of her type built in England. We would, however, refer you to your issue of 20th May, 1898, wherein you fully described and illustrated a similar steamer, the Chebucto, built by the late Sir John Shearer and engined by us. This vessel was tried on 12th August, 1897, and was thereafter boarded up and steamed to her destination at Nova Scotia, where she has continued regularly at work ever since.

When readers abroad see the reference made to England, of course they at once accept this in the larger sense as embracing Scotland, and it is to prevent any error or misunderstanding in this connection that we have drawn your attention to the matter.

The Chebucto had a very smart appearance, and was very much admired on the Clyde. McKie and Baxter.

Copland Works, Govan, Glasgow, December 20th.

COMPOUND LOCOMOTIVES.

Sir,—I have read with great interest the article on compound locomotives by Mr. R. M. Deeley, and also your very able editorial on the same subject.

I was surprised, however, to find that neither Mr. Deeley nor yourself made any reference to the latest type of Midland express engine, No. 999, and her sisters. No. 999 has, of course, the same high-pressure boiler as the compounds, but is fitted with two simple cylinders, 19in. by 26in.; driving wheels, 6ft. 6½in. in diameter; and Mr. Deeley's valve gear.

I am sure that it would be of great interest to readers of The Engineer if Mr. Deeley would inform us why, after building forty-five perfectly successful compound engines, he reverted to the simple type; also whether any comparative trials have taken place between the compounds and the 999 class, and, if so, with what results. Obviously a much better idea of the value of compounding can be obtained from a comparison between the 999 class and the compounds than between the 700 class and the compounds.

I do not think there is much mystery about the non-success of the Webb three-cylinder compounds. The engines were a failure because they had no coupling-rods. The high and low-pressure cylinders were rarely running in synchronism. This accounts for the curious "unevenness" of their performances. Sometimes they ran very well indeed, and at other times very badly. Having no coupling-rods, there was nothing to ensure that the high and low-pressure cranks were in their proper relative positions. Harold Smith.

Bradford, December 20th.

THE INSTITUTION OF CIVIL ENGINEERS.

RAILWAY SIGNALLING IN INDIA.

At the ordinary meeting on Tuesday, the 14th December, Mr. James Charles Inglis, President, in the chair, the paper read was "Railway-Signalling in India," by Mr. C. W. Hodson, C.S.I., M. Inst. C.E. The following is an abstract of the paper:—The author has divided his subject into three parts: signals, interlocking, and block working. In the first part he has given a brief account of the arrangements of signalling which were adopted in the early days of the Indian railways, and how these have been gradually modified from time to time; and he details the latest development, *i.e.*, the introduction of the "warning signal," with an extra green light fixed above the ordinary light of a fish-tailed signal, in order to give an indication by night which has the same significance as the fish-tailed arm has by day. This indication consists, therefore, of a "green over red" light, and signifies "pass cautiously, and be prepared to stop short of the signal ahead." It has been in use for more than six years on several Indian railways, and has been found very satisfactory; and the author suggests that it might with advantage be adopted for use on English railways, in order to do away with the anomaly of the present distant signal, and to abolish the dangerous rule known as "section clear, station or junction blocked." In the second part a brief description is given of various installations which have been put up for interlocking the points and signals at simple roadside stations, mostly designed and made up in India, and the author points out the economy of such gear in comparison with installations supplied by English manufacturers. He expresses the opinion that the objections raised to "key-locking" in some quarters are much over-rated, and points out the economy obtainable by it. In the third part the author describes briefly the "Line clear and caution message" system, which is so widely used in India, in spite of certain serious defects, which he points out. These defects have been largely removed by a drastic revision of the General Rules for Working Railways in India, which was undertaken by a strong committee of official representatives of the principal railways in their various departments, assembled at Simla in September, 1903.

The Harris Level.—We have received from Merryweather and Sons, Limited, Greenwich, a small pocket instrument, the invention of Mr. G. W. Harris, A.M. Inst. C.E. This tool is intended for a variety of purposes, providing various scales for measuring lengths and angles, while an adjustment converts it into what is intended to be an elementary form of theodolite clinometer or level. Its inventor claims for it a wide range of usefulness, and believes that engineers, architects, plumbers, surveyors, and many others will benefit by its use.

How to Learn the Morse Alphabet.—For those desirous of learning the Morse code, the little diagram invented by Mr. C. O. Grimshaw, 57, St. George's-square, S.W., should prove useful. The method of learning is a mnemonical one, the signal for each letter being shown on the chart associated with that letter in a peculiar and easily remembered fashion, so that a mental picture of each is readily formed by the beginner. Copies of this ingenious chart may be obtained from Lake, Sison and Brown, Limited, Victoria-street, S.W.

The Areameter.—We have received from Mr. A. E. Mallandain, 51, Cheapside, London, E.C., a sample set of a new instrument, to which the above name has been given, and intended for finding the areas of figures. The instrument consists of a celluloid T-shaped lamina. The vertical tail of the tee is not, however, straight, being bound on either side by hyperbolæ extending from its foot to either tip of the horizontal arm. At the junction of the horizontal and vertical axes of the figure thus formed, a small V shape is cut, intended for the reception of a pin, about which the instrument can rotate. The method of finding the area of a figure bounded by a continuous line is as follows:—The pivot being placed somewhere near the centre of the figure, the instrument is rotated about it into consecutive positions, the points where the hyperbolic sides cut the periphery of the figure being marked with a pencil or other means, and the instrument moved on right round the figure. Joining the points thus marked on the boundary with the centre we would divide the figure into a number of triangles, which, by the construction of the instrument, must have equal areas. The form has been so chosen that each of these triangles shall have an area of one square inch, so that we need only count the number of ticks made on the boundary line to obtain the area in square inches. A proportional scale engraved on the celluloid enables fractional parts of one square inch to be measured. The instrument can also be used by sliding it along a straight base, and for this purpose a smaller but a similar lamina is provided, which, if used in the manner of the larger, would divide the area into ½ square inches.

SHIPBUILDING NOTES.

The death of Sir Alfred Jones has removed one who exerted a very real influence on shipbuilding. The man who controlled the Elder Dempster Line and its affiliated companies was an important man in the eyes of the shipbuilder. Sir Alfred Jones believed in up-to-date ships, and, while no unnecessary money was spent upon them, they were in every way sound practical jobs, admirably adapted for those particular trades which he himself had created. As many builders know, he was a most accessible man, and we are sure that in technical circles the regret inspired by his death will be as real as in those with which he was more intimately acquainted.

On Wednesday last the Waratah was posted at Lloyd's. That event, coupled with the return of the Sabine to Capetown, removes the last doubt as to the fate of that unlucky ship. The Waratah was built in 1908 by Messrs. Barclay, Curle and Co. for the Blue Anchor Line. She was a modern vessel of dimensions 465ft. by 59.4ft. by 38ft., having a poop bridge and forecastle of considerable length, the passengers being carried in two erections upon the bridge deck. It is idle to speculate on the cause of the disaster, but there could be no possible question of structural weakness, and there also could be little possibility of defect of stability in a vessel of this type under any but very abnormal conditions.

While that may be safely said in this particular case, it may be pointed out that the practice of fitting long erections on the structural deck, intended for the accommodation of passengers, is a growing practice, and one to which, in the nature of things, there must be a limit. No doubt the increasing attention now being paid to passenger accommodation, and the increasing demands made upon the designer in this respect, are responsible for it. Rooms are larger, and are more of the single berth type, and are placed in more eligible positions, from the point of view of the occupier, than ever before. But two results follow, and, as a matter of fact, have been observed in several cases. First, the ships are top-heavy, and depend for safety largely on the extent of side out of the water, which in passenger vessels is, of course, considerable. Secondly, these erections are subject to considerable straining action themselves, and they also impose stresses of no negligible magnitude on the rigid structure upon which they are built. The natural consequence of this is a constant necessity for repairs of damage, which may not, indeed, be serious, but which inevitably are expensive.

A very interesting launch took place from the Wallsend Yard of Swan, Hunter and Wigham Richardson and Co., Ltd., on Monday, 13th inst., when the first of two steamers which that company is building for the Grand Trunk Pacific Railway Company was placed in the water. The Prince Rupert—with her sister vessel—is intended for a special service between Prince Rupert and Tacoma, and is 320ft. long overall by 42ft. 3in. by 18ft. to main deck. The vessel is designed for a service speed of 18 knots, and the accommodation provided for passengers is of the most modern description. These vessels are interesting as marking the beginnings of a new expansion of the trade possibilities of the North-West.

A question very prominently claiming the attention of those connected with ship design is the proposals now being made in various quarters, substantially to increase the frame spacing in ordinary merchant ships. Some time ago Mr. Wortley, of Messrs. Holt, read a paper before the Institution giving the details of his firm's practice in this respect. Messrs. Holt have been the pioneers in this matter as in several others which could be mentioned. If we remember aright, in their vessels the spacing of frames was 36in., associated with thick shell plating and a multiplicity, or what would now be considered so, of side stringers. As before stated, there are several practicable proposals now being put forward in this direction, and it is very probable that the tendency to space frames widely will prove an increasing one, and must be provided for. Especially will this be so in the case of ships of somewhat complicated design, where the cost of labour bears a relatively high proportion to the cost of material.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

The Week.

Trade this week has to contend against the treble effects of stocktaking, political disturbance, and pending Christmas holidays, but the expectation is encouraged that a brisk business—at any rate, in pig iron—may be looked for after the general election in January, and when the retarding influences to the market of Christmas and New Year holidays have been overcome.

Pig Iron Improvement Maintained.

During the past week a considerable weight of pig iron has been sold, and smelters are not now prepared to accept all the business which is offering for next year. Some producers quote future deliveries up 1s. to 2s. per ton, but it is clear that this is by way of safeguarding their output rather than as a real gauge of the strength of the market. Buyers, it is noted, are indisposed at present to concede any more for supplies, save in special cases, which have no great significance. A fair tonnage has been sold for next quarter, and, having regard to the costs of production and the possibilities of trade development early in 1910, smelters have no choice but to assume an attitude of caution. The production of pig iron in South Staffordshire has been curtailed since the winter came in, owing to accumulation of stocks, and this curtailment is now strengthening the market. The leading producers are well sold, and are in no anxiety as to business for next year. South Staffordshire common forge iron this week realises 45s. to 46s.; part-mine, 48s. to 49s.; best all-mine, 85s.; and cold-blast, 115s. Some Northamptonshire houses are asking an advance, but buyers are irresponsive. Values generally are firmer, on the basis of about 48s. for ordinary Northampton grades of forge pigs, while Derbyshire iron is offered at 49s., and the quotation for North Staffordshire forge iron is 50s. and upwards.

Merchant Iron.

There is not much recovery to be noted in the bar iron trade. Prices have fallen to such an unremunerative level as regards South Staffordshire common bars that some ironmasters are leaving the trade alone until the conditions become more propitious. Nut and hurdle bars are still quoted as low as £5 12s. 6d.,

and, as was plainly intimated in last week's report, producers declare that they cannot be turned out at the price. Marked bars are selling more steadily on the £8 basis. There is a regular current of demand for North Staffordshire "crown" bars, but it is only of sufficient volume to keep the mills going about three-quarter time. The rate remains at £6 10s., delivered at ports for the export trade. Gas tube strip iron is still quoted at the standard of £6 5s. and £6 7s. 6d., less 2½ per cent., while hoop iron is £6 15s., rivet iron £6 15s. to £7, and rail rods £7 per ton.

Boom in Galvanised Iron.

There is quite a boom in the galvanised iron trade. The orders for galvanised sheets on foreign account show an increasing tendency, and it is practically certain that the December returns will show a further large improvement in shipments. All the sheet mills are working at high pressure. Demand is so active that it is said to be in contemplation to restart at an early date South Staffordshire black sheet mills, which have been lying idle for six months past. The galvanisers have their hands full, the quotation for 24 gauge corrugated sheets being £11 to £11 5s., f.o.b. Liverpool. Black sheets are firm at £7 2s. 6d. to £7 5s. for doubles, and £7 15s. to £7 17s. 6d. for trebles, with £7 to £7 2s. 6d. as the figure for singles.

Steel Better.

The steel trade, alike in billets and half-product bars and sections, is in rather better condition, and sellers will not book so far forward as buyers would very much like. Native Bessemer billets rule firm at £4 15s. delivered in Birmingham, and Siemens qualities £4 15s. to £4 17s. 6d. per ton. There is some talk of raising prices. But, so far, there has been no decision except with regard to certain special qualities not very widely used, which have been put up 5s. a ton.

NOTES FROM LANCASHIRE.

(From our own Correspondent.)

MANCHESTER, Thursday.

Pig Iron.

THE year just closing has been unsatisfactory to almost all traders. The advance in fuel prices is, however, causing makers to quote higher prices, but, as usual, there is much uncertainty whether the full advance will be realised, as buyers still operate sparingly and for present wants. We may summarise the course of prices in this district as follows:—Lincolnshire No. 3 foundry opened at 53s. to 53s. 6d.; the lowest price registered was in March, 49s. 6d. to 50s. A gradual improvement took place, and in August the figure was 54s. 6d. to 55s; September, 56s.; November, 55s., and closing at 53s. Staffordshire, 52s.; closing price, 53s. Middlesbrough open brands, 57s. 7d. to 57s. 10d., which, with slight variations, was maintained to the end of July. At the end of September it was 61s. 4d. to 61s. 7d., and closed for early delivery at 59s. 7d. to 59s. 10d. In Scotch pig iron Gartsherrie has been variable, ranging from 57s. up to 63s., and closing at 59s. Glengarnock opened at 59s. 6d., closing at 60s.; Eglinton, at 57s. 6d., closing at 59s. 6d. West Coast hematite has ranged between 58s. 6d. to 63s. 6d., closing at 61s. to 61s. 6d., with a premium of 2s. 6d. per ton more asked for next year's delivery. East Coast hematite opened at 57s., closing at 60s. 6d., both f.o.t.

Finished Iron.

Lancashire bars, hoops, and sheets have experienced little change.

Steel.

This remark applies to steel generally. There has been no particular fluctuation to note, except that there is an upward tendency at the close for English billets, which have been well held at from £4 10s. to £4 15s. per ton, and foreign billets are now practically off the market.

Copper.

There has been a very quiet feeling to report in this particular department, and the close is somewhat dull. Sheets opened at £76, declining to £70, the worst figure being £74 per ton in January and November. The close was about £1 per ton lower. Tough ingot and best selected have advanced or receded on about the same lines as sheets; the opening was £62 and the close £63 per ton. Tubes have been rather variable, the lowest being 8⅞d. and the highest 9d.; brass tubes and condenser close about ½d. lower; rolled brass, brass wire, and brass turning rods show little change. Yellow metal a shade easier.

Sheet Lead.

Has been fairly steady throughout, ranging from £16 to £17 per ton.

Tin.

English ingots have had an upward movement all through the year; commencing at £128 10s., they have gradually advanced with few exceptions to £147 10s. per ton at the close.

The Lancashire Coal Trade.

There was a fair attendance on the Coal Exchange. Household fuel was firm, but there was no advance, as was generally expected. Steam and furnace coal steady. Shipping coal brought about 3d. per ton more money.

BARROW-IN-FURNESS, Thursday.

Hematites.

There is a further improvement to note in the hematite iron trade of the district, and there is a fuller inquiry for forward deliveries of metal. The position of makers is more satisfactory alike as regards the amount of business being done and the prospects of a still better trade in the early future. Consumers are showing more disposition to cover their requirements in the early months of next year, and this is some proof of the opinion that markets are going up, and that it is better to buy at present prices than wait until a better demand arises, with a consequent increase in prices. Several makers are, however, so well assured of the future of the trade that they are hesitating about doing much forward business, and will only make transactions at fully 1s. per ton higher. Makers are asking 63s. 6d. net f.o.b. for mixed Bessemer numbers, and warrant iron sellers are at 61s. 6d. net cash, buyers 6d. less; three months 63s. 4½d. buyers, 63s. 4¾d. sellers. The business in special qualities of hematite shows an improvement, and makers believe there will be a much more active demand before long. Ferro-manganese and spiegeleisen are in steady request. There is a fair trade in charcoal iron. Iron ore is in rather better request, and prices are at 12s., 14s. 6d., and 18s., net f.o.b. for ordinary, medium, and best descriptions net at mines.

Steel.

There is a much better market in the steel trades. A brisker inquiry has arisen for shipbuilding material, but whether this will act as an influence to bring the plate mills, so long idle, into operation remains to be seen. There is a better inquiry for rails and for merchant classes, but not much is being done in foundry steel.

Shipbuilding and Engineering.

Vickers, Sons and Maxim have been entrusted with the order to build a new battleship cruiser for the Admiralty—one of the four contingent Dreadnoughts. This order is all the more important because a few weeks ago the Vickers firm obtained the order to build the engines for a sister ship - the Lion—which has just been laid down at Devonport. These two orders, with other orders for Government mountings, will represent more than three millions of money.

Shipping and Coal.

The shipping trade is only moderately employed, but the exports show an increase of over 100,000 tons as compared with the corresponding period of last year. Coal and coke are steadier, with a disposition to increased firmness.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Holidays.

THE holiday feeling has been evident for some time in regard to business. In the coalfield the miners will cease work on Friday, the 24th inst., and it is not expected that the stoppage will last beyond the following Thursday. At the East End establishments, where the heavy trades are carried on, the holidays will generally extend from Friday evening until Monday, the 3rd January. Christmas falling on a Saturday is looked upon favourably in industrial quarters, as it allows continuous holidays for the time. The cessation of labour is largely taken advantage of for repairs and alterations, as well as, in a considerable number of instances, for stock-taking purposes.

House Coal—Official Advance.

The severe weather which set in suddenly on Sunday has had the usual effect of stiffening the rates in household fuel. It was announced on Monday that the collieries had raised the price 1s. per ton, the advance to take effect the following day. This is the official confirmation of the increased price which has been unofficially obtained for some time. It leaves our quotations of last week unchanged, as they were brought up to the current rate of business. Best Barnsley, 12s. 6d. to 14s. per ton; secondary sorts, from 10s. 6d. to 11s. 6d. per ton. There has been a considerable pressure on the house coal pits in view of the Christmas holidays, and this is being accentuated by the stormy weather. The requirements of London and the Southern and Eastern Counties markets are fairly heavy, chiefly for the better grades. The local demand is also active.

Steam Coal—Railway Contracts.

Interest in the steam coal trade centres in the question of the renewal of locomotive contracts. The railway companies offer an advance of 6d. per ton on last year's prices, and the coalowners stand out for an advance of 9d. per ton. Nothing further has been done in bridging the difference, and, as we have already stated, the railways are still receiving pretty heavy deliveries under existing contracts. They are also picking up "spot lots" to a considerable extent. There has been increased buying for works, with a view to tide over the holidays. The demand for hard coal for shipment is well maintained, and helping somewhat towards the present firm tone in what is regarded as the slackest period of the year.

Gas and Small Coal.

The gas companies and Corporation gas departments have been receiving rather heavier deliveries of late. This feature, however, is usual at the present season. Some business is reported in "spot lots," mainly for foreign markets. The gas contracts are made at midsummer, and the arrangements then come to represented a general reduction of 6d. per ton on last year's price. Small coal continues a good market, as it has been doing most of the year. The activity at present is, of course, largely due to holiday requirements. The best qualities of small coal are in principal request. The chief trade in the higher grades is with Lancashire and Yorkshire textile districts, the qualities for which have not altered in price for a long time, ranging from 4s. 6d. to 5s. 6d. per ton.

Coke.

Furnace coke maintains the firmer tone noted last week. Coke, with little exception, has been rising steadily during the greater part of the year, beginning in January at 10s. per ton for best washed, and 9s. to 9s. 6d. per ton for unwashed, and finishing in December at 12s. 6d. to 13s. per ton for best washed, and 11s. 6d. to 12s. per ton for unwashed.

Pig Iron.

Deliveries have been fairly good of late, but now the holiday feeling is apparent, and very little more will be done this side of 1910. A firmer tone is prevalent, and better business, with improved values, is confidently looked for early in the New Year. Makers of Lincolnshire and Derbyshire irons have not been eager to press sales for some time, as they anticipate increased prices later on, and, in addition, are sold well forward. Current quotations, all net and delivered in Sheffield and Rotherham, are as follows:—Hematite: West Coast, 68s. to 70s. per ton; East Coast, 65s. to 67s. per ton. Lincolnshire: No. 3 foundry, 52s. 6d. per ton; No. 4 foundry, 51s. 6d. per ton; No. 4 forge, 51s. 6d. per ton; No. 5 forge, mottled and white, 51s. 6d. per ton; basic, 52s. 6d. per ton. Derbyshire: No. 3 foundry, 52s. per ton; No. 4 forge, 50s. 6d. per ton.

Bars, Hoops, and Sheets.

Languor still pervades the finished iron trade and its allied branches. Bar iron is exceptionally depressed. Quotations: Bars, £6 10s. per ton; hoops, £7 10s. per ton; sheets, £8 10s. per ton.

Steel, &c.

Fresh orders of consequence in steel are not looked for to any extent towards the close of the year. It is evident, however, that a more hopeful feeling is prevalent with regard to next year's prospects. More inquiries are reported, and with the disturbing factors of electioneering out of the way, it is expected the market may pick up. The home market is at present the most disappointing, and is not likely to greatly improve until shipbuilding yards and engineering establishments experience a general revival. There are reports of more activity in both directions, but the improvement has not been pronounced enough to influence the demand for marine specialities to any considerable extent. High-speed steel and tool steel generally have been steadily in request for the United States, the Colonies, and several of the continental markets. The file trade is still quiet, as it has been for most of the year. Some fair orders for machinery for use in steel works are reported to have been received for Japan.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Pig Iron.

RATHER to the surprise and satisfaction of most traders there has been a strong improvement in demand for and prices of Cleveland pig iron, and indeed all kinds of pig iron within the last ten days. Generally people did not expect any change till after the elections, as they and the holidays might be counted upon to check business. But when least looked for there has sprung up a brisk business both on prompt and forward account, and the market at the time of writing is active and buoyant. Naturally traders are sanguine, seeing that the improvement should set in at such a time as this, and they are very hopeful that something better than the present year's trade will be experienced in 1910. The indications certainly are now favourable to better prices and brisker demands, especially as the situation has improved so much in the steel trade and at the foundries. It must be acknowledged that the revival of business has not been so marked in Cleveland pig iron as it is in hematite iron, and whereas the prices of the latter have risen half a crown in about a week, those of Cleveland iron have only advanced 1s. per ton. No. 3 Cleveland pig iron on Tuesday last week was being sold at 50s. 3d. per ton for early f.o.b. delivery, but now 51s. 3d. must be paid, with 1s. more for delivery over the first quarter of 1910. Cleveland warrants have risen from 50s. 1d. cash buyers to 51s. 3½d. this week, some advance being reported every day. No. 1 Cleveland G.M.B. is now at 53s. 6d.; No. 4 foundry at 49s. 9d.; No. 4 forge at 49s. 6d.; and mottled and white at 49s., all for prompt delivery, with 1s. per ton more for delivery up to the close of next quarter. United States consumers and merchants have begun again to inquire for Cleveland iron, but it cannot be reported that any actual business has resulted. Some Canadian orders have, however, been booked this week, and more are in course of negotiation. Canada has lately bought a good deal of pig iron from Teesside—hematite as well as ordinary Cleveland brands.

Hematite Pig Iron.

After long waiting, there is at last a somewhat lively state of business, though this is hardly a favourable time for a revival. However, the activity in the steel industry and the increased demands of all other works which consume hematite pig iron, together with the very pronounced improvement in the shipbuilding trade, have had a good influence, and brought about the opinion of buyers that the time has fully arrived when they ought to buy as freely as possible for delivery ahead, and that the longer they wait the more they are likely to have to pay for what they will need. Consumers generally have been in the market during the last ten days, more particularly Sheffield firms, but they find producers more independent than they have been for a long time, for their position is much better than it has been for nearly three years, and they have fair orders already on their books for execution over the first half of next year. Demand having become more pressing, and the cost of production being increased and likely to increase still further, there has been a smart advance in prices of hematite this week. Representatives of some of the leading Sheffield steel manufacturing firms were last week on Teesside, but it is reported that the negotiations for buying them mostly fell through, in the first place, because the makers of the hematite iron were not prepared to tie their hands with respect to deliveries in the second half of the year, and that was the period for which the consumers chiefly wanted to buy. More than that, the consumers were not prepared to pay a high enough premium over the prompt rate to tempt the producers. When they offered for the second half of the year only as much as was being quoted for delivery in the first two months, the negotiations were not likely to lead to business. Good orders have this week been booked by Teesside firms from Sheffield and elsewhere for execution over the first half of the year. The makers appear already to be tolerably well supplied with orders for execution in the first quarter of the year, and some over the second quarter also, and it was hardly likely that selling prices would fail to move upwards with almost everything favourable to advances. In the early part of last week consumers could get mixed numbers of East Coast hematite pig iron for early delivery at 60s. per ton, a figure which had been ruling for several weeks, but makers put up their quotations to 60s. 6d. before the close of the week, and this week to 61s., then to 61s. 6d., and on Tuesday to 62s. 6d. for prompt and January delivery, and for beyond that till the end of the quarter 65s. is asked and paid.

Ore and Coke.

For a considerable time there has been no business in Rubio ore, and the merchants would not quote for delivery next year, as they could not induce the Spanish mineowners to name prices for 1910, and they are the masters of the situation now. For several weeks 17s. 6d. per ton for Rubio ore delivered o.i.f. Middlesbrough was the nominal rate for early delivery, but this week sellers have rather surprised consumers by quoting 19s. per ton for prompt delivery, and 19s. 6d. for delivery over the first half of next year; in fact, 19s. 3d. has been paid for over the latter period, and some merchants ask even 20s. There is keen competition to secure supplies of Rubio ore, for it is wanted not only by British users, but also by German and United States. Coke is increasing in price, because the supply is hardly equal to the demand; the manufacturers, indeed, take care that it is not, and keep a considerable number of ovens out. They are the more inclined to do that as some of them say they can sell the coal with more advantage and profit to themselves as coal than if they convert it into coke. The price of ordinary furnace coke for early delivery at Middlesbrough is fully 18s. per ton—the best price of the year, and 4s. per ton better than the minimum. Coke is in better request on export account, so that the tendency is towards higher prices.

Shipments of Pig Iron.

The shipments of pig iron from the Cleveland district have improved, especially on foreign account, but it is certain they will fall off next week, it being generally a holiday period. Exports are reported to the United States, but it is in completion of orders which were secured in the early autumn. American consumers are not buying now; indeed, they are not even inquiring, but there are inquiries from Canada, which it is expected will result in business, though the shipments will not be made until the spring.

Manufactured Iron and Steel.

It cannot be said that there is any improvement in the finished iron trade, but the situation is undoubtedly better in the steel industry; works are more regularly employed than they have been for fully two years, and the tendency of prices is upwards. The makers of steel angles have advanced their quotations 5s. per ton—the first change there has been in their prices for months—and they now ask £5 12s. 6d. for ship angles. For iron ship angles the quotation is £7; for steel and iron ship plates, £6; for steel bars, £6; for iron bars, £7; for steel hoops, £6 5s.; for steel strip, £6 2s. 6d.; for steel sheets (singles), £7 5s.; for iron ship rivets, £7 5s., all less 2½ per cent. f.o.t. Galvanised and corrugated steel sheets are at £11 5s. per ton, less 4 per cent. for 24 gauge in bundles and f.o.b. Heavy steel rails are at £5 5s. per ton net f.o.b., and cast iron railway chairs at £5 10s. At the Newport Rolling Mills, Middlesbrough, which have hitherto been engaged in the manufacture of iron plates, the new owners—the Newport Rolling Mills, Limited—propose to enter also upon the production of steel plates, and the necessary plant will shortly be laid down. It is reported that Sheffield capitalists have been inquiring for a suitable site for steel works in the neighbourhood of Middlesbrough.

Coal and Coke.

On the whole the coal trade in Durham and Northumberland has been very brisk this month, there having been a better demand on export as well as home account, and a good time next year is expected. Higher prices are looked for, and they will be needed if the prognostications about the greater cost of working due to the adoption of the Miners' Eight Hours Act turn out to be correct. It is generally expected that there will be no stoppages of work when the Act comes into force on January 1st, as

practically all the arrangements have been amicably settled now; but the details have not yet been made known. To put themselves in order, however, the notices to the miners to terminate their hirings have been duly issued. Prices generally are stronger, best steam being at 11s. to 11s. 3d.; best gas at 11s. 3d.; seconds gas, 10s. to 10s. 3d.; coking, 9s. 6d. to 10s; bunkers, 10s. to 10s. 6d.; and smithy, 10s. to 10s. 3d., all for early delivery. Coking coal is very satisfactory in price, and some firms sell it as coal rather than convert it into coke, the consequence being that there is hardly as much coke being produced as the market needs, and the price of this is advancing; fully 18s. per ton must be given for furnace coke delivered equal to Middlesbrough.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

The Increase of the Shipping Trade.

THE great and steady increase of the shipping trade of Glasgow has necessitated in recent years a large extension of dock accommodation, and the movement of the shipbuilding and engineering works farther down the river has rendered the present cross-river communication quite inadequate. Every effort has been made to house the artisan population in the near neighbourhood of the works, with the result of creating populous towns like Clydebank. But there has been, along with the expansion of industry and trade, an extraordinary development of the traffic across the river, and the present bridge and ferry accommodation has been found quite inadequate to cope with the increase. Not to speak of the growth of the import trade, the returns of the Board of Trade show that during the last ten years the exports of manufactured articles from the Clyde have more than doubled, rising from the value of £10,378,000 in 1898 to £22,121,000 in 1908, an increase in one decade of over 100 per cent., and that, too, notwithstanding that the last-mentioned year was one of serious depression. With all this extension, it will be readily understood that the pressure of both passenger and vehicular traffic, especially the latter, has become extreme. The Clyde Trustees and the Corporations of Glasgow and the adjoining towns are now earnestly considering what can be done to meet the difficulty. The main obstacle to the erection of bridges farther down the river is that they would impede much of the shipping traffic into the harbour and the docks. Swing bridges would cause serious delay to traffic, and high-level bridges would entail enormous expenditure; but the problem has to be faced, and that without delay, for at present numerous vehicles have to make a detour of miles to get across the lowest of the bridges, and in doing so they cause much interruption to the general traffic of the city.

The Pig Iron Market.

There was a stronger tendency in the pig iron warrant market towards the end of last week, ascribed partly to the fact that selling of warrants by tired holders had ceased, allowing some recovery in prices. Some of the recurring strength was, no doubt, also due to inquiries received by merchants for supplies of iron in the early months of the coming year, although it is not yet clear to what extent inquiries will materialise into actual business. A feature of the market since last report has also been a considerable demand for Cumberland hematite warrants, by which other classes of hematite iron were also favourably affected The business in Cleveland warrants has been of considerable extent in the last few days, and business has been done from 50s. 3d. to 51s. cash, 51s. 2d. to 51s. 8d. one month, and 51s. 5d. to 52s. 4d. three months. Cleveland warrants have also changed hands at 51s. 6½d. for delivery on 28th February.

Scotch Makers' Pig Iron.

The special brands of Scotch pig iron have had a firmer tendency generally, and some makers are quoting 1s. advance on the figures of last week. It is stated that good bookings have been made for shipments well into the first six months of the coming year, and that there is an assurance of a favourable demand at home, and particularly with English consumers. The f.a.s. quotations at Glasgow are, for Monkland, No. 1, 57s. 6d.; No. 3, 55s. 6d.; Carnbroe, No. 1, 60s.; No. 3, 57s.; Clyde, No. 1, 62s. 6d.; No. 3, 57s. 6d.; Gartsherrie and Calder, Nos. 1, 63s. 6d.; Nos. 3, 58s.; Summerlee and Langloan, Nos. 1, 64s.; Nos. 3, 58s. 6d.; Coltness, No. 1, 86s.; No. 3, 58s. 6d.; Eglinton, at Ardrossan or Troon, No. 1, 59s.; No. 3, 57s.; Glengarnock, at Ardrossan, No. 1, 65s.; No. 3, 59s. 6d.; Dalmellington, at Ayr, No. 1, 61s. 6d.; No. 3, 56s. 6d.; Shotts, at Leith or Glasgow, No. 1, 63s.; No. 3, 58s; Carron, at Grangemouth, No. 1, 64s.; No. 3, 58s. per ton. There are 43 furnaces making hematite pig iron, 36 ordinary iron, and 5 basic iron, the total of 84 thus in operation in Scotland comparing with 77 at this time last year.

The Hematite Trade.

There has been a very considerable business in Cumberland hematite pig iron in our market since last report, almost entirely for future delivery. The price has improved from 61s. 9d. to 63s. 3d. per ton in the case of purchases for delivery in three months. It has been pointed out that as the stock of this class of iron is small, any decided inquiry is apt to induce a rapid upward movement in price, and that a turn in the market might likely produce as quick a decline. However this may be, the values of hematite iron generally have been influenced in an upward direction, Scotch hematite having risen 2s., and merchants are now quoting 65s. for delivery at the West of Scotland steel works. The output of Scotch hematite has recently been somewhat increased. Hematite ore is firm in price, and, indeed, the high cost and anticipated scarcity of the ore to which attention has been specially called had no doubt a considerable influence with those operators who are buying Cumberland warrants. In the past six days thirteen cargoes of ore reached the Clyde.

Pig Iron Shipments.

The shipments of pig iron from Scottish ports in the past week amounted to 4575 tons, compared with 4858 in the corresponding week of last year. The United States took 100 tons, India 175, France 10, Australia 145, Italy 150, Germany 50, Holland 75, Belgium 55, China and Japan 600, other countries 573, the coastwise shipments being 2641 tons, against 3200 in the corresponding week. The arrivals at Grangemouth of pig iron from the Cleveland district were better than usual, amounting to 11,612 tons, and showing an increase of 1761 tons, compared with the quantity received in the corresponding week of last year.

Finished Iron and Steel,

There has been little change in these departments of trade. Quite a number of works, both iron and steel, have been unable to obtain full employment. The new work coming to hand is reported to be going mainly into the hands of merchants, who continue to control a large amount of the business, and to purchase in the most advantageous directions as to price in all cases where quality can be guaranteed. It is expected that recent orders received by shipbuilders will exert a favourable effect. Makers of malleable iron are still indifferently employed. In the locomotive engineering trade work has become slack, so that some of the men are being discharged, and it is uncertain when they will be re-employed.

The Coal Trade.

The coal trade has been deriving material benefit from the continuance of cold weather. House coal is in brisk demand all over the country, and recent advances in prices are well maintained. The colliers have been making large outputs in view of the holidays, so that there has rarely been any difficulty in obtaining full supplies. The only trouble in this direction is ascribed to railway traction, about which a good deal of complaint is being made, the policy of the companies at present being directed rather to the saving of outlay in running fewer trains than the earning of money by extension of facilities. There is an impression that if the companies would drop their demurrage policy, which so far has produced little besides irritation, and devote their energies to the accommodation of traders, it would be better for all parties concerned. The shipping trade in coal has been good, and the recent advances in prices are still quoted by merchants.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Last Week's Coal Trade.

NOTWITHSTANDING unfavourable weather, the fair quantity of tonnage coming in enabled coalowners to despatch a good average total, and on Saturday a tolerably good week was closed by Cardiff sending away 40,000 tons, and Newport, Mon., 13,000. Prices were firm on several days without any case of advance; in fact, the tendency to improve from 16s. best steam to 16s. 9d. and then advance to the 17s. rut, as shippers hoped, was not realised, and prices ended with "sticking" at 16s. 6d. The demand this side of the holidays was stated by a prominent member on 'Change to be quiet, shippers having practically obtained all they require. Interest is now centred on the outlook for the New Year. I note a substantial order for 5000 tons best steam coal for Australia, and 120,000 tons, Griffin's coal, Nantyglo, for the Great Southern and Western Railway of Ireland, at about 14s. 6d. Newport, Mon. It was reported last week that Cardiff had sold steam smalls over the New Year in large bulk at 8s. per ton. Cardiff quotations on Saturday were 8s. 9d. to 9s. 3d. best, but cargo smalls were offered at 6s. 9d. to 7s. 6d.

Latest Quotations, Cardiff.

Prospects were regarded on 'Change this week as improving, and higher figures are likely for the beginning of the year. Tonnage arrivals have been considerable, and stocks are rapidly disappearing. Small steam advancing. With harder weather, and a better tone in the labour market, all classes of coal are in stronger favour. Latest prices: Best large steam, 16s. 3d. to 16s. 6d.; seconds, 15s. 6d. to 16s.; ordinaries, 14s. 6d. to 15s.; best drys, 16s. 3d. to 16s. 9d.; ordinary drys, 14s. 6d. to 15s. 3d.; best washed nuts, 13s. to 13s. 6d.; seconds, 12s. 6d. to 13s.; best washed peas, 12s. to 12s. 6d.; seconds, 10s. to 11s. 6d.; very best smalls, 9s. to 9s. 6d.; best ordinaries, 7s. 9d. to 8s. 6d.; cargo smalls, 6s. 9d. to 7s. 6d.; inferiors, 6s. to 6s. 6d.; best Monmouthshire black vein, 15s. 3d. to 15s. 6d.; ordinary Western Valleys, 14s. 6d. to 14s. 9d.; best Eastern Valleys, 13s. 9d. to 14s. 3d.; seconds, 13s. to 13s. 3d. Bituminous: Very best households, 17s. to 18s.; best ordinaries, 15s. to 16s.; No. 3 Rhondda, 17s. 3d. to 17s. 6d.; brush, 13s. 6d. to 13s. 9d.; smalls, 10s. to 10s. 6d.; No. 2 Rhondda, 13s. to 13s. 3d.; through, 9s. 6d. to 10s.; smalls, 7s. to 7s. 6d. Patent fuel, 15s. to 15s. 6d. Coke: Special foundry, 24s. to 27s. 6d.; foundry, 19s. to 20s.; furnace, 17s. to 17s. 6d.; pitwood, 19s. 6d. to 20s.

Newport Coal.

Market opened well, and especially large cargoes were entered for Natal, Cape Town, China, Japan, and Civita Vecchia. Good tone for forward business. Latest:—Best black vein, 15s. to 15s. 3d.; Western Valleys, 14s. 3d. to 14s. 6d.; Eastern Valleys, 13s. 6d. to 14s.; other kinds, 12s. 6d. to 13s. 3d.; best smalls, 7s. to 7s. 6d.; seconds, 6s. 3d. to 6s. 9d.; inferiors, 6s. to 6s. 3d. Bituminous: Best house coal, 15s. to 15s. 6d.; seconds, 14s. to 14s. 6d. Patent fuel, 15s. to 15s. 3d. Coke: Foundry, 18s. to 19s.; furnace, 17s. to 17s. 6d. Pitwood, 19s. 6d. to 19s. 9d.

Swansea Coal.

Considerable animation on 'Change. The successful opening of the new dock, the ending of a long period of suspense, appears to have given new life to the district generally, and the large attendance this week discussed buoyantly the outlook. Steady to firm, with upward tendency, was the general characteristic of the anthracite trade. Latest quotations: Best anthracite, large hand-picked, 23s. to 24s. net; second malting, 21s. to 22s. net; big vein, 17s. 6d. to 19s., less 2½; red vein, 12s. 6d. to 13s. 6d., less 2½; machine-made cobbles, 23s. to 24s. net; Paris nuts, 25s. 6d. to 26s. net; French nuts, 26s. to 28s. net; German nuts, 25s. to 26s. net; beans, 18s. 6d. to 19s. 6d. net; machine-made large peas, 11s. to 12s. 6d. net; fine peas, 10s. 6d. to 11s. net; rubbly culm, 5s. 6d. to 6s., less 2½; duff, 2s. 6d. to 3s. net. Steam coal: Best large, 17s. to 18s.; seconds, 14s. 6d. to 15s.; bunkers, 9s. 6d. to 10s. 6d.; small, 7s. to 9s. Bituminous: No. 3 Rhondda, 18s. to 18s. 6d.; through, 14s. 9d. to 15s. 6d.; small, 10s. 3d. to 10s. 6d. Patent fuel, 13s. to 13s. 6d., all less 2½ per cent. Coal quotations f.o.b., net cash 30 days. A coal authority observes: Quotations for January loading were above current level of prices.

Iron and Steel.

Substantial shipments of rails were made this week by way of Newport and Cardiff. From Newport 3750 tons were sent in arranged portions to Colombo, Madras, and Calcutta. On the 17th inst. 500 tons of rails were despatched to Singapore *viâ* Cardiff. Larger quantities of ore have come in principally to Newport and Briton Ferry from Bilbao and Santander. Ebbw Vale and Blaenavon, also Neath, have been receiving consignments of ore; the latter also of pig iron from Warrington, and Newport from Workington. Large quantities of steel bars have been sent of late to Lydney, chiefly from Newport, Mon. Pig iron has come in as usual from Grimsby. The works at Dowlais are giving increased yields, and mills are well occupied on tin bar, for which there is an increased demand. Market quotations not issued in time for despatch, but prices remain. The leading works are all quoting the same price, according to syndicate arrangements.

Tin-plate.

A good buoyant tone prevails, and last week business was as brisk as ever. From the works the receipts were close upon 80,000 boxes. Shipments were again good—88,763 boxes, and stocks now are 104,459 boxes, as compared with 174,402 boxes. Large loadings expected to be made this week to America, Alexandria, and Rotterdam. The Swansea tin-plate industry is reported as exceptionally brisk. The two large mills started last week are evidence, remarked a member on 'Change, that large sheets are not in future to be the monopoly of northern manufacturers. Two more mills are being brought into operation this week. No list of prices issued, but it was currently reported that values are improving, and tin-plate likely to advance, following upward figures quoted for tin.

Swansea Valley Industries.

Steel trade firm. Considerable activity shown at Baldwin's, Landore, and a good yield of pig iron recorded. This is encouraging, though Swansea imported 880 tons last week. Copper trade maintains a fair briskness. Spelter even busier, and the various factories at Lower Forest, &c., full of trade. Foundries reported all doing well, and fitting shops all actively engaged. The year is ending well for the trade.

Llanelly.

A better tone is reported in iron and steel, and a substantial make in bars, though manufacturers complain that dumping is active. By all makers it is now admitted that the resolution to keep to the policy of the best materials is meeting with its reward. Home make finds acceptance in all quarters, and it is currently discussed that the demands of America are increasing, and likely to increase on that account. Four of the new mills are now in full activity, and are doing well. Coal is exceptionally brisk. The traffic from the leading anthracite collieries and from Barry Port and Gwendnaelt is quite justifying the hopes entertained, and increased locomotive power is being obtained.

Port Talbot.

Total of imports and exports last week was an advance upon the preceding, and amounted to an increase of nearly 7000 tons. Among the items of exports I note 125 tons tin plates, 122 tons steel plates.

The Colliers and Future Agreement.

At a meeting of the Miners' Federation, held in Cardiff on Monday, the outlook with regard to the colliers and the notice handed in was considered to be more favourable. It was decided that the Secretary, Mr. Dalziel, be instructed to arrange a further meeting of the Conciliation Board on December 29th, when the workmen will have some suggestions to make with a view of obviating the necessity for notice to be given on January 1st. If the Board agree, then a general conference to be called for December 31st. Hopes are freely entertained that the district may, as a result of more favourable views entertained, be spared any trade conflict, which at one time was feared might be a long and disastrous one.

AMERICAN NOTES

(From our own Correspondent.)

NEW YORK, December 15th.

ALL industries connected with the manufacture of equipment for railroads are crowded to the limit of their capacity. The car building works and the locomotive works are leading in activity, and some car builders have contracts, the execution of which extends up to next summer. The Pressed Steel Car Company has just purchased 5000 tons of iron for delivery next quarter. Bar iron has advanced sharply, the summer price being 1.40 dols., and the present price 1.70 dols. Some makers are asking 1.80 dols. All lines of material are held at the strongest prices. The output of pig iron is equal to the demands, but that of semi-finished steel is below. The merchant bar mills are also overcrowded. Some railroad companies are putting in capacity, and propose to rely upon their own shops for their future car supply. The plate mills are more overcrowded than any other branch of the industry. A number of large concerns are sold up to May 1st. Prices on plates have advanced from 1.35 dols. to 1.60 dols. An order for 4000 freight cars will be placed in a short time by a New England road. Other companies are formulating their requirements for next year. The Pennsylvania has just ordered twenty-seven shunting and five consolidation engines. The Republic Iron and Steel Company will hasten the erection of six open-hearth furnaces at Haselton, Ohio. The Southern Railway has placed an order for 1000 freight cars, and the Missouri-Pacific has also placed heavy orders calling for delivery before April 1st. The steel industry is quieter than it has been for four months. All industries needing equipment are figuring, but their necessities and a number of orders will be placed early in January, to be followed later by a succession of orders that will go very largely to employ the various equipment manufacturing plants to their fullest capacity. It seems to be generally conceded that a higher level of prices will be reached for many lines of manufactured products, though it is the intention of the managers of the steel industry to use their power to maintain prices at a level as nearly as possible. The copper market is steady and unchanged. During November there was a moderate curtailment, and it will be continued to some degree during the present month. In the North-west the curtailment is influenced by the strike of the switch men, which is impeding traffic to a considerable extent. The average price for electrolytic is thirteen and three-fourths. Export of copper up to last Saturday of this month was 6884 tons. All large concerns handling copper are holding to the standard price. Arrivals of tin up to last Saturday 1033 tons, amount afloat 2500 tons. The supply of tin-plate is light, and premium prices are occasionally paid for prompt delivery.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

IN consequence of the demolition of their offices at No. 8, Delahay-street, under the Public Offices Sites (Extension) Act, 1908, Messrs. Horne and Co. have removed to 35, Old Queen-street, Westminster, S.W.

THE directors of the Midland Railway have appointed Mr. H. Fowler to be chief mechanical engineer, Mr. A. J. Owen superintendent of operations, Mr. L. C. Geach superintendent of motive power, Mr. J. Badwell superintendent of the passenger service, and Mr. E. R. Ward general passenger agent.

EDWIN DANKS AND CO. (Oldbury), Limited, inform us that after official inspection of "Imperial" water-tube boilers under construction in the company's works, the Admiralty have placed the firm upon their list of manufacturers of water-tube boilers. The Water-tube Boiler and Engineering Company, 11, Queen Victoria-street, E.C., will be pleased to supply any further information concerning these boilers.

DRESSING GRINDSTONES.—In our last issue we published a short account of a new device for trueing grinding wheels under the above heading. We are asked to call attention to the fact that the tool dealt with is intended for emery and carborundum wheels.

CONTRACTS.—Smith, Major and Stevens, Limited, have just been instructed by the Lords Commissioners of the Admiralty to supply and erect on board the new Dreadnought battleship H.M.S. Neptune four of their electric passenger lifts.—Lassen and Hjort have secured an order for three large water softening plants from the North-Eastern Railway Company.

THE INSTITUTION OF MECHANICAL ENGINEERS.—An extra general meeting will be held on Friday, 7th January, 1910, at 8 p.m., when two papers will be read and discussed:—"The Application of the Pitot Tube to the Testing of Impulse Water-wheels," by Mr. W. Rankine Eckart, Associate Member, and "An Account of a Visit to the Power Plant of the Ontario Power Company at Niagara Falls," with extracts from papers by officials of the company, by Mr. C. W. Jordan, Associate Member.

CRYSTAL PALACE ENGINEERING SCHOOL.—The Wilson Premium for the best paper read before the Crystal Palace Engineering Society during the present session has been awarded by the Council to J. P. Watson for his paper on "Types of British Locomotives;" other papers read during the session were "Tunnelling," by W. H. Baker, and "Railway Signalling," by L. E. Sawyer. The Premium was presented to Mr. Watson by Mr. W. M. Mordey on the occasion of the 111th distribution of certificates of the above school on Friday, December 17th, at which he presided.

ROYAL INSTITUTION OF GREAT BRITAIN.—As already announced, a Christmas course of experimentally illustrated lectures, adapted to a juvenile auditory, on "Modern Electricity," will be given by Mr. William Duddell, F.R.S.: On Tuesday, December 28th, (1) "First Principles;" Thursday, December 30th, (2) "Electrical Instruments;" Saturday, January 1st, 1910, (3) "Röntgen Rays;" Tuesday, January 4th, (4) "The Generation of Electricity;" Thursday, January 6th, (5) "Electric Oscillations;" and on Saturday, January 8th, (6) "Electric Lighting." Lecture hour, three o'clock.

NOTES FROM GERMANY, FRANCE, BELGIUM, &c.

(From our own Correspondent.)

The Silesian Iron Market.

LIFE increases in most branches of the Silesian iron industry, and compared to this time last year the present state of the iron market may be considered satisfactory. Foreign demand is good, and there is more work holding out; especially with the Northern and Danube districts a large business is being carried on. Girders are in active request, though this is a quiet period for that article. Merchant bars and hoops meet with good request on home and on foreign account. Prospects generally are pretty favourable as regards the development of spring business.

Rheinland-Westphalia.

The market for iron and steel was pretty firm during the week. In the Siegerland rather less has been bought than previously, because dealers have already purchased largely for the next quarter, and buyers do not care to place orders for a further period. Rhenish-Westphalian ironworks are reported to have resolved to show reserve as to forward contracts, but there is a hopeful tone prevailing generally, and employment all round has increased. The Bar Convention has recently been prolonged for another year. Latest accounts from the Düsseldorf 'Change of the 17th inst. state prices for bars to have been raised from M. 104 to M. 110, as compared with M. 104 to M. 108 in the beginning of December. Sheets stand at M. 127.50 to M. 135 p.t., against M. 127.50 to M. 131 p.t. last month.

The Steel Convention.

Sales of the Steel Convention in November of this year have been 390,355 t., as compared with 420,894 t. in October, and against 341,578 t. in November last year. This shows deliveries to have been 30,539 t. lower than in October of this year, and 48,777 t. higher than in November, 1908. Of the deliveries in November 130,480 t. were semi-finished steel, as compared with 133,775 t. in October of this year, and against 111,932 t. in November, 1908; railway material, 153,265 t., against 158,112 t. in October, and 158,306 t. in November last year; sectional iron, 106,610 t., against 129,007 t. in October, and 71,340 t. in November, 1908.

Coal in Germany.

House coal sells freely in Rheinland-Westphalia and in Silesia, and the tone of the coal market generally is more lively than before. It is reported from Berlin that the negotiations regarding the joining of the Central German and Saxon brown coal works have been satisfactorily concluded. The principal office of the Syndicate is to be in Leipzig.

Austria-Hungary.

Nothing of interest can be told of the iron and steel market in Austria-Hungary. A somewhat dull trade is done in raw and in finished iron, few forward orders being booked. Coal is tolerably firm and in good request, dealers buying freely.

Slackening Off in Belgium.

With the beginning of the present month a slight decrease in demand could be felt in the iron and steel industry, but the tone of the market continues firm nevertheless; the healthy condition of the German iron trade will probably be felt in Belgium too later on. Iron bars have not changed in price, but for bars in basic, that realised up to £5 p.t. f.o.b. Antwerp, in November, only £4 18s. p.t. is now quoted; still, the concessions granted, even in special cases, never exceed 1f. to 2f. p.t. Girders show a firm tendency, and the rail trade is favourable, large contracts from Brazil, Ezypt and Argentina having been taken at prices that have not unfrequently shown advances of 3s. to 5s. p.t., according to the weight of the order. A languid tone characterises the plate trade, while the business in sheets continues fairly good. The Belgian coal market maintains a quiet but firm condition. Producers, as a rule, show reserve as regards forward orders, because increasing life and higher prices are expected for the next quarter. Consumers, on the other hand, receiving favourable offers from German pits, hesitate to place their orders with inland firms, and so there is comparatively little business transacted in the coal trade just at present. In the Liège and Charleroi district a want of wagons continues to be complained of, demand being particularly lively in these parts, whereas the pits of the Centre and Mons district are doing a moderate business only. Briquettes continue depressed both in demand and in price.

Accounts from Sweden.

From July to September of this year only 66 blast furnaces, 186 furnaces, 15 Bessemer, and 53 Martin furnaces have been in blow, against 86 blast furnaces, 220 furnaces, 18 Bessemer, and 53 Martin furnaces in the same quarter last year. Output from January the 1st to September the 30th of this year was:—

	1909. t.	1908. t.
Pig iron	444,500	427,200
Blooms	83,000	113,900
Billets in Bessemer	43,300	59,700
Billets in basic	190,000	263,000

Total export till October 31st was for 1909, 252,900 t., in 1908, 276,300 t.; of these pig iron amounted to 87,700 t. in 1909 and 94,000 t. in 1908; cast iron, 7300 t. in 1909 and 4600 t. in 1908; blooms, 14,800 t. in 1909 and 16,900 t. in 1908; bars, 87,700 t. in 1909 and 98,000 t. in 1908; drawn wire, 16,700 t. in 1909 and 18,300 t. in 1908; billets, 14,100 t. in this year and 16,300 t. in 1908. Prices generally show a tendency upwards. Owing to suspension of work during part of the year output has been rather limited, and stocks are low, especially in malleable iron and steel. Increasing work is now reported to be coming in both for forward and for immediate delivery.

ROYAL METEOROLOGICAL SOCIETY.—The monthly meeting of thi Society was held on Wednesday evening, the 15th instant, at the Institution of Civil Engineers, Mr. H. Mellish, president, in the chair. Dr. W. N. Shaw, F.R.S., read a paper on "The Variations of Currents of Air Indicated by Simultaneous Records of the Direction and Velocity of the Wind." He said that, in order to form a mental picture of the changes which are taking place in the amount of air flowing past an anemometer, we need to take into account the changes of direction as well as the changes in velocity. He had endeavoured to combine these in what he called a "Vector Diagram," and he pointed out some interesting results which he had obtained from such diagrams. Two practical and interesting papers by Mr. W. G. Reed, jun., were read by the Secretary. These papers formed part of the work done in the course in climatological research given in Harvard University, Mass., under the direction of Prof. R. de C. Ward. The first paper was "A Critical Examination of South American Rainfall Types," the object being to make a simple yet accurate map, showing the seasonal distribution of rainfall in South America. The second paper was "The Study of Phenomenal Climatology." The suggestion has several times been made that treatment of weather elements by days and months is arbitrary and unnatural for places not within the tropics. The author points out that in latitudes subject to cyclones the distribution of weather elements depends largely upon the relation of cyclones and anticyclones; and he, therefore, suggests that the cyclone is a more rational unit than the day or the month.

BRITISH PATENT SPECIFICATIONS.

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

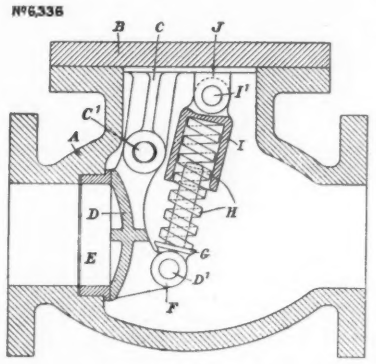
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-office of opposition to the grant of a Patent.

STEAM GENERATORS.

6336. March 17th, 1909.—IMPROVEMENT IN ISOLATING VALVES FOR STEAM BOILERS FOR THE PROTECTION OF LIFE, James Halliwell, of Fairfield-terrace, Cherry Tree, Blackburn, Lancaster, engineer.

This invention relates to isolating valves for steam generators, and has for its object to provide new or improved means of preventing the breakage of same by "knocking" due to fluctuations of pressure and the pulsating action of steam. A represents the valve casing, and B the cover; C is a lug cast on the under side of cover B, to which lug is pivoted, by means of a pin C^1, the flat-

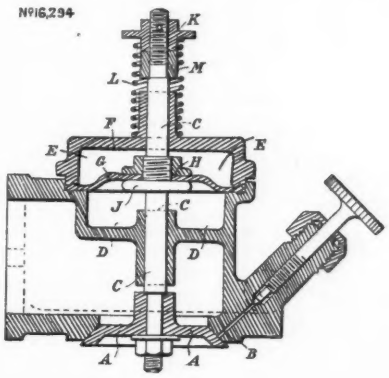


faced valve D; E represents the valve seat; F is a lug cast on the back of valve D, to which is pivoted, by means of a pin D^1, a guide pin G; J is a second lug cast on the under side of cover B, to which box I is pivoted by means of a pin I^1, and in which box the upper end of spring H is disposed. Spring H is adapted to impart a slight pressure to valve D, at any position of opening, against the steam pressure generated in the boiler, so as to close the valve gradually as the pressure is reduced, and finally maintain it upon its seat.—*December 1st*, 1909.

INTERNAL COMBUSTION ENGINES.

16,294. July 13th, 1909.—IMPROVEMENTS IN CONNECTION WITH CARBURETTERS FOR INTERNAL COMBUSTION ENGINES, Harry Heatly, of 110, Cannon-street, E.C.

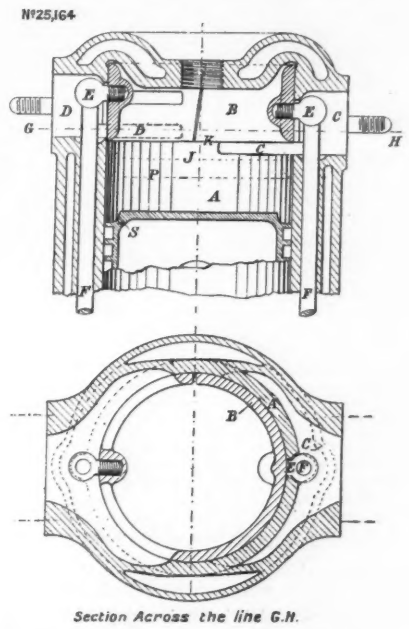
The atomising valve A, having at its lip a valve-controlled inlet B for fuel, is carried upon a spindle C in a casing forming part of a carburetter. The valve spindle C passes up through a chamber, the lower part D of which is formed in the casing, while the upper part E is formed in a cover F. The cover F is secured to the casing by flange and set screws, and between it and the casing is tightly held a flexible diaphragm G held on the spindle C by a nut H co-acting with the collar J thereon. The spindle C passes out through the cover F, and between an adjustable flanged nut K on its outer end, and the cover is arranged a spring L tending to close the valve A, a lock nut M being provided for securing the



nut K when it has been adjusted. Naturally, air at atmospheric pressure fills the chamber upon each side of the diaphragm G. This air during downward movement of the valve A is compressed in the lower chamber part D and expanded in the upper E. The resistance offered to the downward movement of the valve is therefore equal to the sum of the difference of pressure from atmospheric in each of the two chamber parts D E, which pressure difference obviously increases in rapid ratio—how rapid depending upon the capacity of the chambers—with continued movement of the valve. Since the movements of the valve are very rapid, the possibility of leakage of air into and out of the chambers D E from and to the atmosphere is extremely slight, but, if need be, the possibility of this leakage could be avoided by arranging a diaphragm at either end of a centrally partitioned chamber connecting the diaphragm adjacent to the spindle directly thereto, and that remote by a stirrup or like device passing around the outside of the chamber. Or equivalent devices to like end may be used. There may be substituted for the diaphragm a piston substantially air-tight in the chamber.—*December 1st*, 1909.

25,164. November 23rd, 1908.—AN IMPROVED VALVE MECHANISM FOR INTERNAL COMBUSTION ENGINES, Horace John Howard, of "Briarley," Cherry Orchard, Staines, Middlesex.

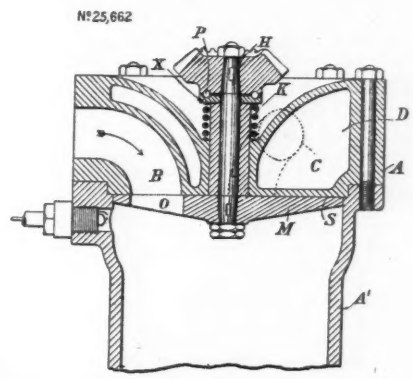
The object of this invention is to minimise the noise, to give a freer passage for the inlet and exhaust gases than they would have passing under mushroom valve heads, and to provide means for lubrication. The valve consists of a broad flat split ring covering annular slots cut through the walls of the working cylinder on opposite sides, and arranged to move in an axial direction within the cylinder, in such manner that it opens and closes one of the slots or ports at each end of its travel, its mid position shutting both ports gas-tight. This valve is designed to keep the combustion space clear of projections, rods, or arms, its actuating mechanism being attached to the ring from the outside, through the cylinder walls, to two trunnion pins, which project into the ports, vertical slots extend upwards from the ports to give them the necessary up and down movement, the ring being made broad enough upwards to cover these slots when the ports are closed. The lower edge of the ring uncovers the exhaust port, which is cut lower, by its own width, than the inlet port, which is preferably opened by a registering port or ports cut through the ring itself;



or the ports can be reversed, the lower one being used as the inlet. To lubricate the working surfaces the lower edge of the ring is arranged to overlap the path of the piston, and so use the lubricant brought up by a shoulder on the latter. When the ring is in its mid position J its lower edge just clears the highest point reached by the shoulder S on the piston. The valve may be operated by a grooved cam in both directions worked on the two to one shaft, or by a surface cam in one direction, return being by a spring or springs. The dotted lines P, J and K show the three positions of the valve; A is the cylinder, B the split ring valve, C the exhaust ports, D the inlet ports, E E the trunnion pins, F F the actuating rods, S the shoulder on piston.—*December 1st*, 1909.

25,662. November 27th, 1908.—IMPROVEMENTS IN MEANS FOR CONTROLLING THE ADMISSION AND EXHAUST OF INTERNAL-COMBUSTION ENGINES, Thomas Horsley, Herbert Oswald Horsley, and Henry Benjamin Horsley, all of 10, Coney-street, York.

This invention relates to valves for internal-combustion engines of the type in which a rotary disc valve is provided having an aperture or apertures which on the rotation of the valve communicate with the inlet and exhaust ports at the required time, and has for its object to provide a valve of this type mounted to operate on the inner surface of a separate cylinder head or cover which is provided with curved inlet and exhaust ports opening from the exterior directly through the disc valve into the cylinder at positions determined according to the cycle of operation. The head or cover A of the cylinder is advantageously separate from



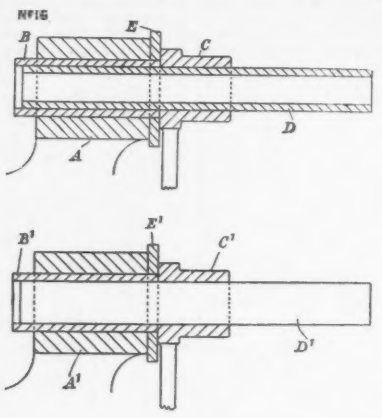
the main part A^1 and slightly enlarged. The head or cover A is provided with the respective inlet and outlet passages B C, and it is preferred to provide the head or cover A water jacketed as at D, and the under face of the cylinder head or cover is provided with a flat face S, against which is disposed a disc valve M of substantially the same diameter as the cylinder bore provided with a segmental port O, the valve being mounted upon a spindle. The respective inlet and exhaust passages B, C, it will be understood, are directed downwardly to open out on the inner face S of the cylinder head or cover, and are of such curved shape as to be directed out in a direction at right angles to the centre line of the cylinder. The spindle upon which the valve is mounted has its outer protruding extremity H^1 fitted with bevel or other gear by means of which movement is communicated to the valve synchronising with the movement of the crank shaft, and a spiral spring K is provided or other means to maintain the valve against the under face of the cylinder head or cover, which spiral spring may advantageously abut against a loose ring, between which and the boss of the bevel wheel a ball race P is provided, by which friction may be minimised.—*December 1st*, 1909.

DYNAMOS AND MOTORS.

16. January 1st, 1909.—IMPROVEMENTS IN OR RELATING TO DYNAMO ELECTRIC MACHINES, John Taylor, of Mather and Platt, Limited, Salford Ironworks, Manchester.

This invention relates to improvements in the brush gear of dynamo electric machines, whereby the construction is simplified

and cheapened, and the number of parts is lessened by the elimination of nuts, screws, and the like. The upper engraving shows a cross section of the spindle and rocker arm constructed in accordance with the invention. In this figure the tubular spindle D is placed in a hole in the rocker arm A and insulated therefrom by the sleeve of insulating material B and the washer of insulating material E. The tube D also passes through the hole in the eye

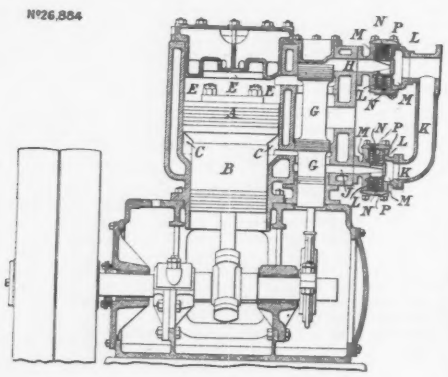


of the cross connecter or terminal C, and, after being placed in position, is expanded by means of any suitable tool so as to be firmly fixed in the rocker arms or connection eyes or terminals. In the lower engraving is shown a slight alternative arrangement, in which the holes in the rocker arm A^1 and in the connecter eyes or terminals C^1 are shrunk on to the brush-holder spindle D^1, which in this case may be solid, a sleeve B^1 and washer E^1 of insulating material being interposed between the spindle D^1 and the rocker A^1.—*December 1st*, 1909.

PUMPING AND BLOWING MACHINERY.

26,884. December 11th, 1908.—IMPROVEMENTS IN SINGLE-STAGE AIR COMPRESSORS, Stephen Evans Ailey, of Sentinel Works, Polmadie, Glasgow.

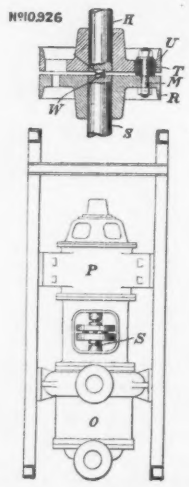
The trunk piston, of otherwise usual construction and form, has parts A B of two diameters, the greater A above and the lesser B beneath, thus forming a down-stroke compression chamber C between the annular area formed by the reduction of the cylinder to fit the lower smaller piston part B and the annular piston area due to the difference in area between the lesser lower piston part B and the greater upper piston part A, while between the upper surface of the piston part A (the piston head) and the cylinder



cover is formed the usual up-stroke compression space E. Inlet and discharge of air from the two compression spaces C E are controlled by a piston valve G, between the discharges H J from which and the delivery K from the compressor are automatic valves controlling that delivery. These valves consist of thimbles L fitted in cylindrical cavities and bearing upon seats in passages formed in valve-boxes M arranged in the delivery pipes, springs N within the thimbles, and acting between them and covers P on the valve-boxes, being provided to operate them.—*December 1st*, 1909.

10,926. November 25th, 1909.—IMPROVEMENTS IN AND RELATING TO CENTRIFUGAL PUMPS, Jens Orten Boving, of 72-74, Victoria-street, Westminster, London, S.W.

This invention relates to an improved method of coupling with

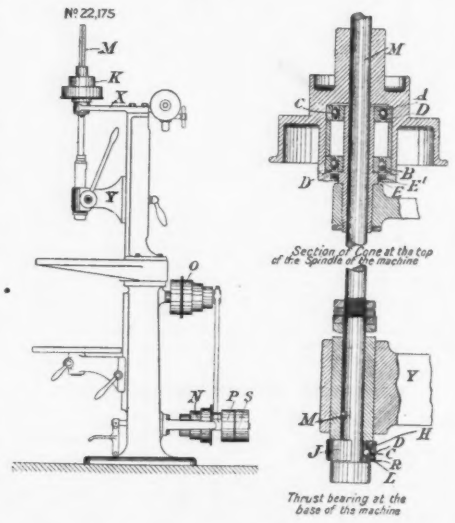


the wheel spindle of a centrifugal pump, which spindle is balanced against end-thrust and placed with its axis vertical, a motor whereby the pump is driven, the coupling being so designed and constructed as to permit of a certain degree of flexibility in respect to the alignment of the spindles of the motor and the pump wheel, and yet enable the weight or thrust of the motor to be transmitted in a frictionless manner to the pump spindle. In the arrangement shown, which in many cases will be the most convenient, the suction end of the pump O is downward. When a high speed of revolution is adopted in such a combination a special design of coupling will be requisite, whereby the weight of the rotor of the motor P will be transmitted of the pump spindle S in order that it may be water-borne, and wherein also a degree of flexibility is provided permitting the spindle of one rotor to undergo a small displacement relatively to the other either in an angular direction or laterally. A suitable coupling for this purpose is shown, drawn in section to a larger scale. The spindle S of the pump is fastened to a flange R to which are secured a number of stud bolts M, on which bolts are threaded a plurality of washers T of leather or equivalent material. These washers fit loosely into enlarged orifices provided in the flange U which is secured to the spindle H of the motor. By this known device, a torque can be transmitted from one spindle to the other and at the same time the two spindles will be free to undergo a small relative displacement. The extremities of the two spindles may butt directly on one another, but preferably bearing discs W are interposed, one of which is advantageously made slightly convex. An alternative construction in which the desired flexibility is provided in the manner explained, but in which the end-thrust is transmitted from one spindle to the other through balls mounted in a ring, is also illustrated.—*December 1st*, 1909.

MACHINE TOOLS AND SHOP APPLIANCES.

22,175. October 20th, 1908.—IMPROVEMENTS RELATING TO DRILLING MACHINES, W. W. Ward and Co., Limited, and Walter Deakin, both of Lionel-street, Birmingham.

The ball bearings employed in this drilling machine consist of an inner ring A and outer ring B, these rings being of hardened steel. A series of steel balls C is interposed between the two rings, balls being covered by a gun-metal cage or ring D. Leather dust washers E E^1 are secured at the side of the ball bearings. In the sensitive drilling machine illustrated the drill spindle M is movably mounted in the arms X Y, and to its upper end is keyed the cone

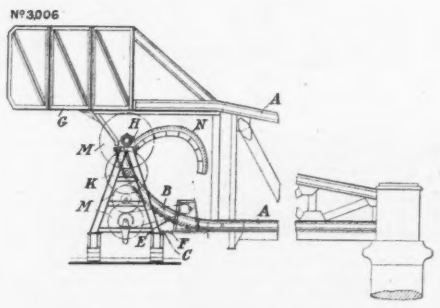


pulley. This pulley is driven by a belt from another pulley O on the upper countershaft, the belt passing over the guide pulleys. The cone pulley O is driven by a belt from the pulley N on lower countershaft, which carries the usual fast pulley P and loose pulley S. The cone pulleys K and O, guide pulleys, and loose pulley S are each mounted on ball bearings and provided with leather dust washers, as also is the lower countershaft carrying pulley N. At the base of the drill spindle is a thrust bearing consisting of a casing J and hardened rings H L, a series of balls C and a cage D, the ring L being secured by the expanding spring ring R.—*December 1st*, 1909.

MISCELLANEOUS.

3006. February 8th, 1909.—IMPROVEMENTS RELATING TO MOVABLE BRIDGES, the Cleveland Bridge and Engineering Company, Limited, of Darlington, Durham, and Joab Haigh Walker, of White Draw Bridge, Carmarthen.

This invention consists in constructing a rolling lift bridge in which the turning movement of the leaf or leaves of the opening span is effected by a pinion or pinions in a fixed position co-operating with a rack or racks integral with the bridge portion, and so curved that the pinion or pinions shall always remain in engage-



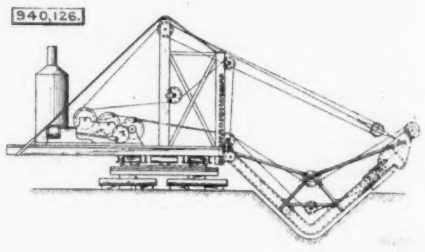
ment therewith. The invention further consists in the improved construction of bridges hereinafter described. In the form of the invention illustrated the movable leaf A is formed with a circular end B adapted to roll on the bridge support C. Teeth E are provided on the circular portion and adapted to engage with recesses F in the bridge support when the bridge is turned about the horizontal axis, which moves in a horizontal direction as the leaf turns, and a suitable balance weight G is provided. The rotation of the leaf about the horizontal axis is effected by means of pinions H on each side carried by strong frameworks K mounted on the bridge supports, the pinions H being rotated by means of electric motors, or by hydraulic, steam, gas, or hand power through trains of wheels M. The shaft H extends across the width of the bridge, and connects the gear trains on each side of the bridge when more than one pinion H is employed. The pinions H engage with racks N fixed to the leaf, and of such a curved form that they will always remain in engagement with the pinions whatever be the position of the leaf in its movement about the horizontal axis. It will be obvious that the invention is applicable to bridges of other design than that illustrated, and that two movable leaves may be used meeting in the middle of the span, the girders being arranged on the cantilever principle, or other convenient manner.—*December 1st*, 1909.

SELECTED AMERICAN PATENTS

(From the United States Patent-office Official Gazette.)

940,126. DRAINAGE EXCAVATOR, *M. G. Bunnell, Chicago, Ill., assignor to F. C. Austin, Chicago, Ill.—Filed December 11th*, 1908.

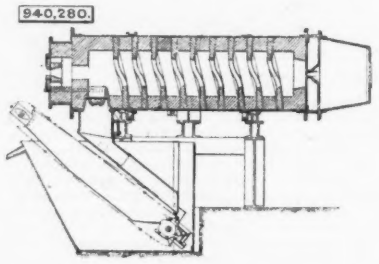
The inventor makes twenty-one claims. The fifth runs as follows :—In a drainage excavator, a vertically swinging runway, an excavating bucket, means for causing the bucket to travel back



and forth on the said runway, means whereby the bucket dumps without leaving the runway, and means for effecting a vertical and bodily raising and lowering of the entire runway, whereby the depth of the ditch or trench may be varied without varying the slant or angle of the sides thereof.

940,280. ANNEALING AND HARDENING FURNACE, *W. S. Rockwell, New York, N.Y., assignor to W. S. Rockwell Company, New York, N.Y.—Filed December 4th*, 1908.

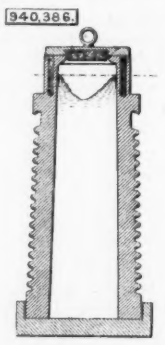
The inside of the tube is fitted with spiral fire tiles, by which



the articles being treated are moved through the furnace by its rotation and discharged through a door which opens once at each revolution. There are fifteen claims.

940,386. INGOT MOULD, *E. Gathmann, Bethlehem, Pa., assignor to Gathmann Engineering Company, New York, N.Y., a Corporation of Maine.—Filed June 14th*, 1909.

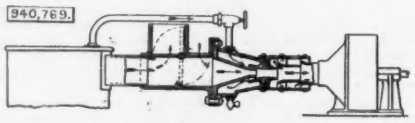
This invention has for its object the retaining of the steel in a fluid condition at the top while it cools at the bottom. The lower portion of the mould is ribbed or roughened to favour heat radia-



tion, while the upper portion is surrounded by heat insulating means, and is closed at the top by a cap or covering of insulating material which is a poor conductor of heat, and which has no chemical effect on the material from which the ingot is cast. There are five claims.

940,769. MOTIVE-POWER SYSTEM, *A. Wilstam, Los Angeles, Cal.—Filed March 1st*, 1909.

This patent is for the combination of a steam generator, a flue for conveying the gaseous products of combustion, and provided with a damper, and having a flue gas discharge and an air inlet, a combined superheater and injector connected to the flue. The superheater having steam connection with the generator and means for discharging superheated steam into one or more nozzles



of the injector, so as to create a flowing current of mixed flue gases and steam, [illegible]ery, exposed to the open air and consisting of a number [illegible] arranged in tandem of successively increasing capacities and adapted to inject atmospheric air into the path of the jet and expand the mixed aeriform fluid, and a turbine motor, into the intake of which the injector discharges. There are four long claims.

OUR MINERAL STATISTICS.

PART III. "Output" of the Mines and Quarries, General Report and Statistics for 1909, made a somewhat belated appearance, not coming to hand until the second week in November. Since the death of Sir C. le Neve Foster, the Blue-book has been without an authoritative name on the cover and fly-leaf. This year, however, we note the name of the Chief Inspector of Mines, who is, of course, Mr. R. A. S. Redmayne. No change is to be noted in the form of presentment of the statistics, which, as formerly, are reproduced as given in the reports of the individual district inspectors. In accordance with our practice in former years we shall confine our review to the metallic and non-metallic minerals other than coal, and this, though mainly from considerations of space, yet to some extent because we feel that British metalliferous mining in its various branches deserves more notice than the very brief references usually made to it by reviewers of this volume would seem to indicate. That more than half of our output of pig iron is made from native iron ore obtained from deposits which show no signs of depletion, is a fact of interest and importance which seems to be by no means common knowledge among engineers. Or again, that in Derbyshire, North Wales, and Scotland we have some of the most productive lead mines in the world, having regard to the areas worked, is insufficiently recognised. It is a common observation that lead mining in Derbyshire is practically extinct, yet the county provided 5262 tons of dressed ore in 1908, over 5000 tons of which we estimate came from the Mill Close mine. We have to estimate the figure because, as in former years, the figures for individual mines are not given in the Derbyshire returns. In all the other lead mining districts it is different, the figures for each mine being given separately.

With regard to the exact source of origin of some of the materials, notably blende and fluor spar, and, to some extent, lead ore and barytes, we have pointed out in former years that it is incorrect to give them as the product of mining, because they have been obtained merely from the dressing of old mine dumps. Probably in the bulk of cases it would prove a very difficult matter to get separate statistics relating to the products of mines and old dumps, especially when both are being worked at the same time, as has been the case for years at the blende mines of Carshield, Northumberland, and Trelogan, Flintshire. Where no discrimination, however, is made it is not surprising that erroneous ideas as to the value of certain mining properties may exist. Old dumps, of course, have only a certain life, and when they are worked out it is only natural that the returns from the working mine near which they are situated should show a decline unless exceptional and satisfactory developments are made underground. Something of this sort is the real explanation of the large falling off in the zinc returns to be noticed in 1908 from the Northumberland and Cumberland district. In connection with this matter of separate returns from dumps, we note with satisfaction that Table 273 of the present volume gives the output and value of tin ore from old dumps at surface of mines. This, as also the reference to arsenical pyrites from dumps, is an innovation which may possibly be carried into other mining districts in succeeding years. Although among the important minerals tin ore is the only one which shows an increase over 1907, yet except in the case of zinc the falling off is in no way serious, and having regard to the continuous fall in values since the first half of 1907 there is really nothing to cause surprise.

Perhaps the most satisfactory feature of the returns is the general improvement shown by Wales, where increases are shown in lead, copper, and iron, while there is only a trifling decrease in zinc compared with England. With regard to the columns in the statistics purporting to give the value of the ore at the mines much might be said. Here, of course, the mine inspectors are largely in the hands of the mine owners, and from what we can judge by perusal of the figures, in many cases we cannot help thinking that the asterisk stating that the value is estimated might be employed more often than is the case. The matter is one of importance and complexity, and justice can not be done to it in the few lines available in a general review like the present: we shall, therefore, dismiss it with merely a word of caution to the uninitiated not to read the values given too closely, but to make further inquiries if information of more than a general character is desired. With respect to the assay values given for lead, copper, zinc, &c., it must not be assumed that the figures are comparable as showing the efficiency of the dressing plant at the several mines, or in different districts. In some cases rich and poor ore are mixed together for purposes of sale, thus reducing the assay value of the rich ore; in other cases the high-grade ore is sold alone, and this assay always figures in the statistics. In many cases the average assay of the ore from a particular mine is obtained from the smelter by the district inspector, the mine owner not concerning himself with the matter. We refer to the point because anyone not conversant with the facts might, for instance, infer that the ore of the Wiregill mine, in Teesdale, of which the assay is given as 77 per cent., has been less efficiently treated than, say, that from the Halkyn mine in Flintshire, for which the figure 83 per cent. is given. As a matter of fact, the bulk of the ore from the former assays 83 per cent. also, but it appears in the statistics as 77, for reasons which have been to some extent explained above.

But to proceed now from the general to the particular, we shall as usual make our individual references in alphabetical order. Arsenic is tabulated both as white arsenic or arsenious acid, and as arsenical pyrites, both of which show a decided increase, though the market price has been considerably lower than it was in 19[illegible]. The great bulk of the arsenical pyrites was obtained from mines and waste heaps in Devonshire, while the white arsenic came principally from the Cornish tin mines, where it is collected as a calcination product of the tinstone. Passing on to barytes, we note that, as was the case last year, the details are headed barium—compounds—instead of barytes—mainly sulphate—as was formerly the case. The reason for the change is not obvious. There are two barium minerals mined in the United Kingdom, the sulphate and the carbonate, and as these are specially indicated, there seems on the face of it no particular object in altering the former title. Barium compounds have a suggestion of lithopone or other bodies into which barytes enter. These, however, could not be ranked with the ordinary minerals as mines products. We do not suggest that anything of this sort has occurred, though we are at a loss to account for the barytes from the West Riding mine having the stated value of over £4 per ton. The values given in other cases vary from 6s. to 20s. per ton for sulphate, while the ordinary price for the carbonate from the Settlingstones mine, Northumberland, is £2 per ton. This year we note that the Nentsbury mine, Alston Moor, is producing carbonate of barytes, the stated value of which is nearly £3 per ton. In 1907 the output of barytes was the highest recorded, and though 1908 shows a reduction, the total of 38,947 tons is a considerable increase on previous records. For some years the New Brancepeth mine, Durham, has been the principal producer of sulphate; but though it still retains the position, its production in 1908 fell off by close on 50 per cent., and it is now very closely challenged by the Wotherton mine, Shropshire, for first honour. The Derbyshire output is quite insignificant, and no developments have taken place in the county at all commensurable with what we find in Durham, Yorkshire, Westmoreland, and Co. Cork.

We have given more space than usual to barytes, because its occurrence and mining have become of increased importance in the last few years, and because the United Kingdom is now one of the principal producing countries. The increased demand, it may be mentioned, is due very largely to the war in so many countries against white lead paint, and the enforced substitution, therefore, of lithopone or zinc oxide, the former being a chemically precipitated mixture of barytes and zinc sulphide.

Cobalt ore has not been raised from the old Flintshire mine for some years, but we may say that during the last two years some development work has been put in hand with satisfactory results, and the formation of a new company to work the mine is in progress. Passing on to copper, it is quite startling to note that the Levant mine, Cornwall, has lost the leading position which it held for so many years, and that the Glasdir mine, Merionethshire, is now the principal producer of copper ore. As far as values are concerned, this mine, with £6580, beats the combined Cornish output of £6317. With regard to this, however, we note that no reference is made in the statistics to the gold content in the Welsh ore. We are not in possession of any details, but understand that the copper from the Glasdir mine, which is in the neighbourhood of the St. Davids' gold mine, carries considerable gold values. It is at this copper mine that the Elmore vacuum plant is at work concentrating low-grade ore, and our prognostications of two years ago with regard to the future of copper mining in North Wales, are amply justified by the returns for 1908.

The difficulty attending the economical concentration of the low-grade copper ores, which exist in so many places in North Wales, has long militated against the mining industry, and in 1906 the output of copper ore was nil. The copper precipitate, which has for so long been produced from the waters of the old Anglesey mines, is excluded from these references to copper mining. Another new mine in North Wales is the Talysarn, in Carnarvonshire, the ore giving the high dry assay of 20.17 per cent. In Ireland only cuprous pyrites was mined in 1908, and the developments of the present year do not come up for consideration. Of course, the state of the copper market has been all against new British ventures, and has had a serious effect upon more than one of the mines in the list under notice.

Last year we foreshadowed a decreased output of fluorspar owing to slackness in the iron and steel trades, and this has come to pass, the output being 34,700 tons against 49,462 tons in 1907. Compared with ten years ago the present output in Derbyshire and Durham is, of course, very great, but it seems doubtful if any further expansion will occur however much the iron trade may improve; and this because of the new American tariff of 12s. per ton, an impost which has brought something akin to consternation into the two producing centres. Unless the home trade shows a very great improvement we shall expect to see a still further reduction when the figures for 1909 see the light. With regard to the tabulated list of Derbyshire mines, the bulk of these are merely old dumps from which the fluor is collected; so far very little of the Derbyshire product comes from mines, though in Weardale the case is different. The production of gold at the well-known St. David's mine in Merionethshire continues disappointing, and the decline from the bumper year 1904, when the value was £73,925, has not yet been arrested.

Proceeding now to iron, the production, though somewhat less than in 1907, remains about 15 million tons, the great bulk of which continues to come from well known and old established iron mines, coal mines, and quarries. We note that Devonshire is a new-comer with 1400 tons of 57.5 per cent. ore, and Somerset with 2556 tons of 55 per cent. also enters the list. A very interesting feature is the return of 12,832 tons of 41.34 per cent. ore from the new Garregfawr mine in Carnarvon, owned by Alfred Hickman, Limited. These deposits have been shunned in the past from their phosphorus contents, but, of course, this impurity has now-a-days no terror for ironmasters. The developments which have been made, including aërial ropeway transit to the Llanberis branch of the London and North-Western Railway, portend an increased output in the current year. The Bryn Castell mine, near Dolgelly, belonging to the Brymbo Steel Company, Limited, is also a new concern, with an output of 2619 tons of 38 per cent. ore. The Coed Llan iron mine in Flintshire shows a rise in its output, but at this property, which has long figured in the returns, work has been largely confined to locating the course and extent of the ore deposit. Judging from the recent boring operations this small hematite mine shows promise of developing into a concern of greater note. Quite recently, we may add, another large iron mining company has commenced work in North Wales. Iron ore, chiefly argillaceous carbonate, has long been obtained to the amount of about 10,000 tons from coal mines in South Wales, and there is nothing which calls for comment as regards this. Glancing at the imports of iron ore, we note a reduction from 8,218,790 tons in 1907 to 6,626,692 tons in 1908, the cause of which needs no particularisation. Newfoundland and Tunis are new to the list of countries whence imported, though the amounts are only trifling compared with Spain.

Passing on to lead mining, it is not surprising that, the fall in the mean price of English pig lead from £19 12s. in 1907 to £13 14s. in 1908, has been reflected in a decreased output of ore, though the fall from 32 533 tons to 29,249 tons is by no means startling. Mill Close, as usual, is the principal producer, with only a slight fall from the previous year. The only English mines showing an increase are Snailbeach, Shropshire, and the small Stang mine recently reopened in Arkendale, North Riding. In Wales the Rhosesmor, in Flintshire, which has come to the front so quickly in recent years, shows a small decrease, while the North Hendre, in the same district, comes very close to it with 2099 tons. It is a great pity that this mine was flooded last spring, just as it had started on a new era of activity and showed such great promise. Features of interest and importance about British lead mining are to be noted at the Scotch mines of Leadhills and Wanlockhead. At the former electric pumping plant is now successfully at work, and at Queensberry mine, Wanlockhead, the new company now in possession is introducing modern developments, which augur well for its future prosperity. This district, despite the riches which have been obtained from it in the past, continues to open up very well, and it is somewhat surprising that more blende is not marketed from the Queensberry mine. With regard to new mines, if we except one or two in Wales there only remains the Norcliff Sough in Derbyshire. Last year's output is lumped with Mill Close, but we shall not be far out in putting it at 100 tons—a figure which will be considerably exceeded this year. This mine now easily takes the second place in the county, and more money is being spent on the new dressing mill than has been the case at a Derbyshire lead mine for many years. The situation of the mine, by the way, is not correctly given in the statistics, but this is of no great moment. Manganese ore continues on the down grade as far as North Wales is concerned, but we notice an output of 256 tons from a new mine at Glandore, County Cork.

The production of tin ore (black tin) was 8008 tons in 1908, against 7080 in the preceding year, though the value was considerably less. This important branch of British mining would require so much of our already exhausted space for adequate reference, that we shall not attempt any examination of the details before us, and so pass on at once to uranium ore, which is returned at the same figure as in 1907, viz., 71 tons, the value, however, being £7550 against £6500. Presumably this came from the Grampound-road mine, though we are only told that it came from the uranium mine. The pitch blende now being obtained from the Trenwith mine, St. Ives, to supply the raw material for the new radium laboratory in London, should go to swell this year's return. In 1908 the price of wolfram ore fell considerably, and we are not surprised to note that the output decreased from 322 tons in 1907 to 233 tons. Despite the increased demand from the steel trade, this mineral now comes from several countries, and the Cornish mines have no monopoly. Coming, in conclusion, to zinc, we have to note a serious falling off in the production of blende, and a very considerable decrease in value, due to the fall in price of the metal. The principal producer is now Great Laxey, in the Isle of Man, instead of Carshield, Northumberland, which now takes the sixth place. It may be mentioned that during last year things were in a somewhat unsettled, not to say critical, state at the Carshield and Nenthead mines, which both belong to the powerful Vieille Montagne Company. The question of abandoning the district had been under consideration, but we are pleased to be able to state that it has been decided to keep on the mines, and a considerable sum of money is now being spent on development work, and the erection of a new dressing mill. This decision, it goes without saying, is of great moment to the population of the isolated village of Nenthead, which depends so largely upon the mines. In 1904 the Nenthead mine was by far the largest producer of blende in Great Britain, with 7322 tons, and with 4140 tons from Carshield, the output of the Belgian company was 11,462 tons, the bulk of which was exported to Belgium for smelting. Teesdale has never been noted for zinc production, but last year 50 tons of blende were raised at Willy Hole mine, belonging to the Teesdale Lead and Zinc Company, Limited. In Derbyshire Mill Close produced 629 tons of 45 per cent. ore, the value of which is given as £786. There seems to be something wrong about this, although the ore is certainly complex. In Cardiganshire the old established Cwmystwyth mine, Devil's Bridge, shows a considerable increase over the preceding year, and now that the county has attracted London and Glasgow capital, it is possible that its mines may revert to something of their former prosperity, with which remark we bring this somewhat lengthy review to an end.

BRITISH AND FRENCH RAILWAY SPEED IN 1909.

The information below preserves the continuity of that formerly furnished annually by the late Mr. Rous-Marten, and endeavours to maintain the high standard of accuracy attained by that gentleman.

The review of the British and French train services covers the summer of 1909, and also the so-called winter programmes, which are arranged to last from October 1st in this country, and from November 1st in France, of the present year, until the summer alterations of 1910 come into force.

The tables enumerating the fastest booked start-to-stop runs are a little differently arranged than hitherto, with the object of giving a better or more representative idea of the locomotive work accomplished by the respective companies. This aim, we think, will be fulfilled by firstly furnishing tables which exclude runs of less than 50 miles in length.

In Table A, however, we include the Lancashire and Yorkshire Railway, although it has no run of the standard length.

Table C enumerates runs of less than 50 miles in length formed during the winter and spring, as dictated by the demand for swift luxurious travel to and from the Riviera, &c. Accordingly, runs which are performed only during the summer, or only during the remainder of the year, are duly noted.

The best performances on British railways, as a rule, are found in the summer time-table. On one or two of the French railways the fastest running is, however, performed during the winter and spring, as dictated by the demand for swift luxurious travel to and from the Riviera, &c. Accordingly, runs which are performed only during the summer, or only during the remainder of the year, are duly noted.

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In Table A, however, we include the Lancashire and Yorkshire Railway, although it has no run of the standard length.

Table C enumerates runs of less than 50 miles in length by the respective British companies, which yield a higher rate of speed than they are credited with in Table A on the longer standard, and also the fastest running by those companies which possess no express run 50 miles in length.

A similar table to the above is not required for the French companies, as none possesses a faster booked run than scheduled in Table B.

Analysing the British and French runs, which are booked at a rate of speed of not less than 60 miles per hour, it is found that, for the first time since this comparison was drawn in these columns, France has lost her considerable lead, and, indeed, during the summer had fallen behind this country.

Unfortunately, this altered state of affairs is not due to an increase of British mile-per-minute timings, but to slight decelerations on the Northern Railway of France, which permeate the whole of its service except that between Calais, Boulogne, and Paris.

Last year the French mileage at this speed totalled 519¾, made up as follows:—Longueau to Arras, 41¼ miles, in 40 minutes, speed 61.9, then the fastest run in France; Paris to Longueau, 78¾ miles, in 78 minutes, speed 60.6; Paris to St. Quentin, 95¾ miles, in 95 minutes, speed 60.5, performed three times; and Paris to Busigny, 112¼ miles, in 112 minutes; speed 60.3. Only one of the above runs remains, viz., Paris to St. Quentin. The quickest timing between Longueau and Arras now is 42 minutes, speed 58.9; that from Paris to Longueau takes 81 minutes, speed 58.3; the two others from Paris to St. Quentin have dropped to 97 and 98 minutes respectively; and that from Paris to Busigny is allowed 114 minutes, speed 59.2.

The British runs at 60 miles per hour are, as before, viz.:—

Darlington to York ...	44¼	miles in 43 min.,	speed 61.7
Forfar to Perth	32½	,, 32 ,,	,, 60.9
York to Darlington ...	44¼	,, 44 ,,	,, 60.3
Total	121		

But from October 1st the York—dep. 9.13 p.m.—to Darlington run has been re-timed to take 45 minutes, speed 59.0, so that at the present moment France again leads with a mileage of 95¾ against ours of 76¾. The longest non-stop runs performed by the principal British and French railway companies are given in Table D.

The old main line of the French State Railways is the only continental railway equipped with track troughs. The Eastern Railway shows a train running from Paris to Chaumont—162¾ miles—without an advertised stop, in 3 h. 6 min., speed 52.5 miles per hour, but it really calls at Troyes—104 miles from Paris—for water.

Table A.—*Fastest Booked Start-to-stop Runs of not less than 50 miles in Length on British Railways in 1909.*

Company.	Run.	Miles.	Time occupied.	Speed, miles per hour	Train.
			h. m.		
Great Western	Leamington to Ealing (Broadway)	100⅜	1 41	59·6	4 30 p.m.
North-Eastern	York to Newcastle	80½	1 22	58·9	9.48 p.m.
Great Northern	Grantham to Doncaster	50½	0 52	58·2	4.26 p.m., Sats. only
London and North-Western...	Willesden to Coventry...	88½	1 32	57·7	9.31 a.m.
Great Central	Marylebone to Leicester *vid* Wycombe ..	107½	1 52	57·5	6.20 p.m.
London and South-Western ..	Andover to Vauxhall	65	1 8	57·4	3.25 p.m.
Midland	St. Pancras to Kettering	72	1 16	56·8	3.30 p.m., W*
Caledonian	Perth to Aberdeen	89½	1 37	55·9	5 58 a.m.
Great Southern and Western...	Ballybrophy to Mallow	77½	1 28	53·0	12.32 p.m., S†
Glasgow and South-Western...	Carlisle and Kilmarnock	91¼	1 46	51·5	8 p.m. North, and 2 6 p.m. South
Brighton	Victoria and Brighton	51	1 0	51·0	11 a.m. D,‡ 1.20 p.m. and 5 45 p.m. U§
Great Eastern	Liverpool-street to Norwich (Trowse) ...	114	2 14	49·9	9 50 a.m , S†
Lancashire and Yorkshire ...	Wakefield to Manchester	48	0 58	49·6	11.55 a.m. and 2 45 p.m., Sats. only East, 3.22 p.m. West, S,† 3 22 p.m. West, W*
South-Eastern and Chatham...	St. Paul's to Margate	73½	1 33	47·4	5.10 p.m.
North British	Edinburgh to Carlisle	98¼	2 11	45·1	9.30 a.m., S†
Mid. G.W. (Ireland)	Mullingar to Dublin	50	1 14	40·5	5.58 p.m.

* W = Winter, from Oct. 1st, 1909. † S = Summer, 1st July to 30th Sept., 1909. ‡ D = Down direction. § U = Up direction.

Table B.—*Fastest Booked Start-to-stop Runs of not less than 50 miles in Length on French Railways in 1909.*

Company.	Run.	Miles.	Time occupied.	Speed, miles per hour	Train.
			h. m.		
Northern	Paris to St. Quentin	95¾	1 35	60·5	1.50 p.m.
Paris-Orleans	Bordeaux to Angoulême	86¼	1 29	58·1	4 25 a.m.
P.L.M.	Dijon to Mâcon	77½	1 23	56·2	12 58 p.m., W
Eastern	Paris to Chalons	107½	1 55	56·0	9 a.m.
State (Western)	Paris and Rouen	86¼	1 36	53·9	8.16 a.m. D, and 9.56 p.m. U
State (Old System)	Chartres to Thouars	147¾	2 47	53·0	12.9 p.m.
Southern	Dax to Bordeaux	92	1 48	51·1	12.53 p.m.

Table C.

Company.	Run.	Miles.	Time occupied.	Speed, miles per hour	Train.
			h. m.		
North-Eastern	Darlington to York	44½	0 43	61·7	1.8 p.m.
Caledonian	Forfar to Perth	32½	0 32	60·9	7.2 p.m.
Great Central	Leicester to Nottingham...	23½	0 24	58·7	2.13 p.m.
Lancashire and Yorkshire...	Liverpool and Manchester	37	0 40	55·4	23 trains
Cheshire Lines	Manchester to West Derby	31½	0 34	55·1	5.10 p.m.
Great Eastern	Doncaster to Haxey	13½	0 15	54·0	5.24 p.m.
South-Eastern and Chatham	Tonbridge to Ashford	26½	0 30	53·0	4.53 p.m.
Belfast and Northern Counties ..	Londonderry to Coleraine	33½	0 41	49·0	3.20 p.m., S
Great Northern (Ireland)	Drogheda to Dublin	31¾	0 39	48·8	6 56 p.m.
Somerset and Dorset	Blandford to Evercreech	27¼	0 34	48·0	10.22 a.m.
Hull and Barnsley	North Cave to Carlton	16	0 20	48·0	5.30 p m.
Tilbury and Southend	Fenchurch-street to Westcliff...	34¾	0 46	45·3	5.5 p.m.
Mid. G.W. (Ireland)	Mullingar to Athlone	28	0 38	44·2	8.21 a.m.
G.N. Scotland	Huntley to Inveramsay	20½	0 27	45·0	4 9 p.m.
Highland	Blair Atholl to Perth	35¼	0 51	41·4	11.5 a.m.

Table D.—*Longest Non-stop Runs.*

Miles.	British companies.	Run.	Time occupied.	Speed, miles per hour
			h. m.	
225¾	Great Western	Paddington to Plymouth (North Road) *vid* Westbury	4 7	54·8
S 209½	London and North-Western	Euston to Rhyl	3 57	52·9
S 206¼	Midland	St. Pancras to Shipley (Curve)	4 5	50·5
175¾	Great Northern	Wakefield (Westgate) to King's Cross...	3 9	55·7
164¾	Great Central...	Marylebone to Sheffield *vid* Aylesbury	2 57	55·8
150¾	Caledonian	Carlisle to Perth	3 0	50·2
S 130	Great Eastern...	Liverpool-street to North Walsham	2 38	49·3
124½	North-Eastern	Newcastle to Edinburgh	2 18	54·1
108	London and South-Western	Waterloo to Bournemouth (Central)	2 6	51·4
S 98¼	North British	Edinburgh to Carlisle	2 11	45·1
91¼	Glasgow and South-Western	Kilmarnock to Carlisle	1 46	51·5
86¾	Great Southern and Western	Thurles to Dublin	1 40	52·0
81¾	Brighton	Clapham Junction to Fratton	1 52	45·0
76½	South-Eastern and Chatham	Cannon-street to Dover	1 38	46·2
	French companies.			
147¾	State (Old System)	Chartres to Thouars	2 47	53·0
S 136½	State (Western)	Trouville to Paris	3 7	43·8
120	Northern...	Arras to Paris	2 3	58·5
112¾	Eastern	Chaumont to Belfort...	2 11	51·6
108	P.L.M.	Laroche to Paris *vid* Héricy	1 59	53·4
92	Southern	Dax to Bordeaux	1 48	51·1
86¼	Paris-Orleans	Bordeaux (St. Jean) to Angoulême	1 29	58·1

NEW CEMENT MILL NEAR MONTREAL.

That American capital appreciates the prospect of the extended use of cement in Canada is shown by the Vulcan Portland Cement Company of New York, which has recently erected a new mill at Longue Point, just beyond the eastern limits of Montreal, at a cost of considerably over a million dollars. The mill is designed for a capacity of 650,000 barrels per annum, and is now in operation. This makes the twenty-third mill now manufacturing Portland cement in the Dominion.

It is evident that the greatest care has been used throughout in the design of this plant, labour-saving devices having been introduced wherever economy would result thereby. The plant is noteworthy in many ways, but of all features its immense reinforced concrete stock house for the storage of finished product stands out predominantly. It is believed that this stock house is the largest of its kind ever constructed.

The plant, of which two general views are given in Figs. 14 and 15 and a plan in Fig. 1, is erected on level ground about half a mile north from the bank of the St. Lawrence River, and is intersected by two lines of railway, the Terminal — an electric railway — and the Canadian Northern Quebec—a standard steam railway. A spur of the electric line runs down to the river. The transportation facilities thus offered enable the company to handle both incoming and outgoing materials to the best advantage. The coal supply is brought by vessels to the company's own dock at the river's edge. The same dock is also employed in making cement shipments by water.

On the north side of the railway lines are the factory offices, the crusher house, the clay storage house and the stone house. To the north of the crusher house is the quarry. The mill building, kiln building, clinker storage, coal storage, coal mill, stock house, transformer house, machine shop and stores are on the south side of the lines. The two parts of the plant are connected by a tunnel under the railways, joining the stone house with the mill building.

The office building is 45ft. by 55ft., of one storey, and of concrete; the clay storage building measures 150ft. by 48ft.; the crusher house, 140ft. by 60ft.; and the stone house, 178ft. by 80ft. They are all on concrete foundations, and have steel skeletons sheeted with corrugated iron. The mill building is 100ft. by 144ft.; the kiln building, 85ft. by 162ft.; the clinker storage, 120ft. by 120ft.; and the coal building, 50ft. by 50ft. These are all steel structures covered with corrugated iron and erected on concrete foundations. The machine shop, transformer house and stock house are of reinforced concrete, being of the following dimensions respectively:—92ft. by 51ft., 45ft. by 46ft., and 242ft. by 105ft. Provision has been made in each case for possible future extensions.

Coal is unloaded from vessels at the company's dock into a hopper, as will be seen by reference to the plan of the dock and coal-handling lines, Fig. 2. The hopper in turn empties into dump-cars running on an inclined trestle into the field of a cableway. By means of a heavy weight lifted by the loaded car on its outward journey the empty car, after dumping, is automatically returned to the hopper. This cableway serves an area 700ft. by 300ft., such a large coal piling ground being necessary from the fact that the whole year's run has to be brought during seven months of navigation season. The coal is transferred by the company's locomotive from the cableway piling ground to the works as required.

Fig. 2 shows how the coal is handled by the cableway to the hopper-bottomed coal cars.

On arriving at the works the cars are run on to an elevated trestle under which is a hopper, beside the coal mill—see Fig. 3. Leading from the hopper is a belt conveyor discharging into a Jeffrey crusher within the building. The crushed coal is then raised by a bucket elevator into a rotary dryer, afterwards passing over a screen to one of three pulverising mills. The coal mill has a capacity of 9 tons per hour. From the mill the coal dust, 95 per cent. of which will pass a standard sieve of 10,000 meshes per square inch, is brought by screw conveyors to one of four coal tanks situated one at the end of each of the rotary kilns in the kiln building, ready for blowing into the kilns.

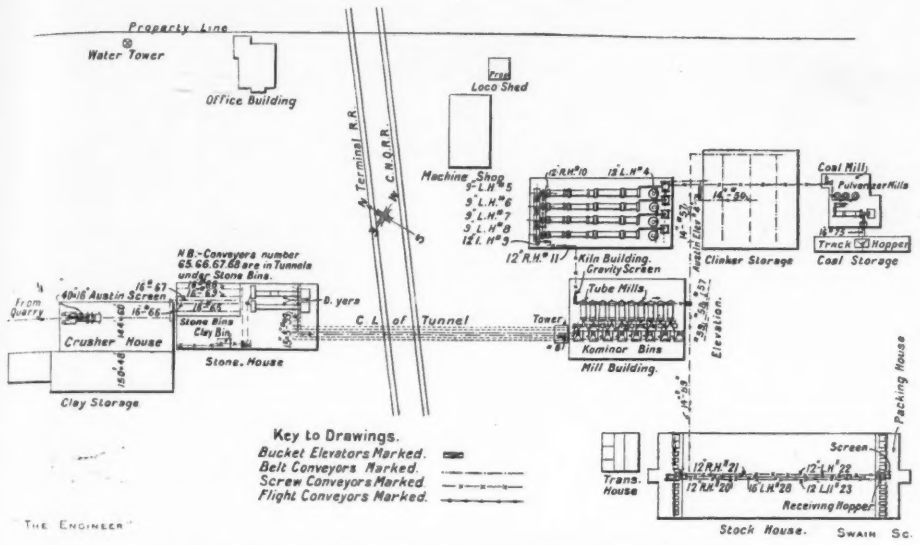


Fig. 1—PLAN OF THE VULCAN CEMENT WORKS, NEAR MONTREAL

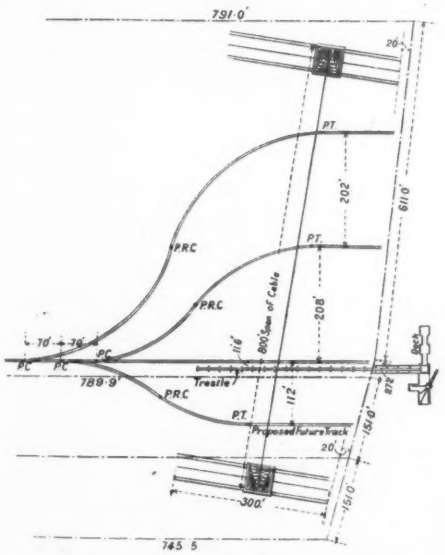


Fig. 2—PLAN OF DOCK AND COAL HANDLING LINES

width of 900ft. over a length of two miles a stratified limestone rock underlies a few feet of clay and gravel. The limestone is remarkably well adapted for Portland cement manufacture, requiring very little correction. Moreover, we gather that sometimes the actual rock as quarried contains the requisite proportion of materials. In fact, at the time of the visit of our representative the mill was actually running on natural rock. The average analysis of the rock is calcium carbonate 75 per cent., silica 18 per cent., iron, aluminum, and organic matter 7 per cent. Tests have been made systematically over the area by diamond drills to a depth of 125ft. below the surface, proving the property to be a practically inexhaustible quarry for the plant. The rock quarries very readily. At the time this article was written the quarry run was dumped by carts into a hopper at the lower end of a 24in. belt conveyor. On arriving at the upper end of this conveyor, after travelling 200ft., the rock is shot automatically into the hopper of a No. 7½ Austin gyratory crusher, which reduces it to 3½in. and less. It then passes in turn by gravity through a revolving screen to a No. 3 crusher of the same type, where it is further reduced to 2½in. The tailings from the screen and from the second crusher discharge at the lower end of a 16in. belt conveyor, which carries it to the stone house. On reaching this building the crushed rock is delivered into any one of six stone bins having a capacity in all sufficient to make twenty thousand barrels of clinker. The bins are of reinforced concrete. Under the floor of the bins are four tunnels, in each of which is a conveyor. Turning at right angles, the rock is brought to a series of automatic weighing machines arranged on the west side of the building. At this point the necessary amount of clay, should any be required, is automatically added to the rock, the amount being determined by the chemist from frequent analyses of the quarry run. Dry clay, obtained on the property, is stored in a 20-ton bin near the clay weighing machine, to which it is brought by a small screw conveyor. The stone weigher and clay weigher each work at the same speed, discharging automatically and simultaneously into a hopper, the delivery of which is on to another 16in. belt conveyor which has its outlet at the stone driers. After passing these driers, which are of the rotary type, the raw product is ready for the grinders, to which it travels on a 16in. belt conveyor. The stone and clay bins of this building have been made large enough to ensure a sufficient supply of raw material being at hand so as to guard against unfavourable weather or trifling mishaps at the quarry end. It also obviates Sunday work at the quarry. Exclusive of the quarrying, and from the time the rock is delivered into the hopper of the first conveyor until the raw materials are ready for the grinders, it is worthy of remark that the work of only five men is required. These men seem to be employed largely in keeping everything in order and watching the machines.

The grinding mill building contains eighteen grinding machines, eight kominor mills—see Fig. 16, page 690—and ten tube mills—Fig. 17. Every one of these has its individual motor, each of the former requiring 75 horse-power, and each of the latter 150 horse-power. A novel feature of the setting of the tube mills is the height above the floor at which they are placed, this being sufficient to enable a horse and cart to be driven directly under the battery and stopped at any one, so that the flint balls used for grinding may be readily passed from the cart into the mill through a manhole provided for the purpose. The belt conveyors are also arranged in a manner worthy of notice. The grinding department serves the whole plant,

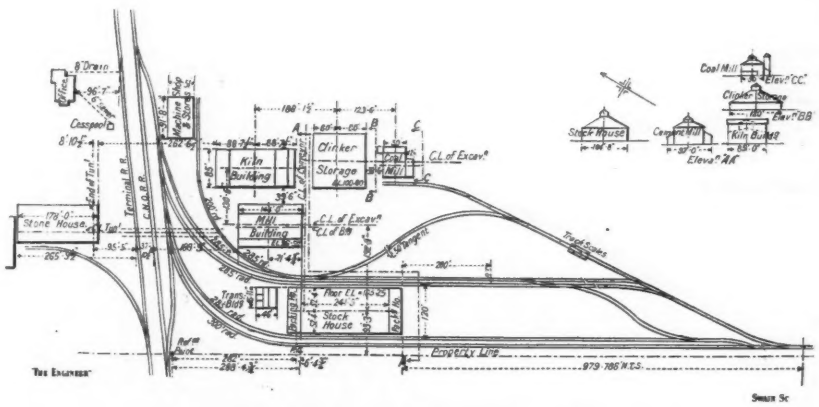


Fig. 3—CEMENT BURNING, GRINDING, AND STORING DEPARTMENTS

pulverising both the unburnt mixture and the clinker. The conveyors are arranged so that any particular machines may be run on the material desired. Each grinder has its own bin and automatic feeding device. Having passed through a tunnel connecting the stone building with the mill building, the raw mixture is elevated to the top of the latter building and carried again by belt conveyors to any one of the eight kominor bins.

Fig. 4—THE KILN BUILDING, WITH CLINKER COOLERS

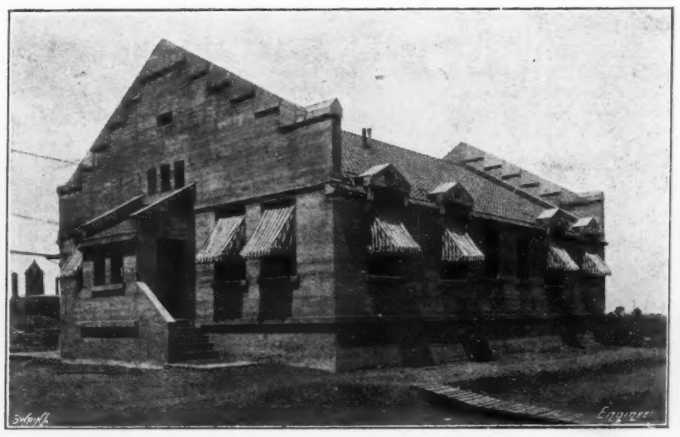


Fig. 5—THE OFFICE BUILDING

The plant is operated by electric power furnished by the Shawinigan Falls Power Company. Current is delivered at the transformer house at the cement works at 40,000 volts, and it is stepped down to 440 volts for use throughout the works. Generally speaking, each machine is

After being reduced by the kominor machines it is discharged over a screen into the tube mill bin. In its journey through the tube mill it is further reduced to a sufficient fineness to pass 95 per cent. through a standard 10,000 mesh sieve. Leaving the tube mill, again passing over a

screen, the raw meal enters a screw conveyor for its passage to the kilns.

There are four rotary cement kilns, each 125ft. long, 7ft. 6in. diameter at the front, and 7ft. at the rear—see Figs. 4, 18, and 19. These machines are all mounted on concrete foundations, and are driven by a 75 horse-power motor through Moore and White variable-speed cones. Arriving by the screw conveyor at the desired machine the raw meal is fed into the upper end of the kiln, where the temperature is about 600 deg. Fah. At about 20ft. to

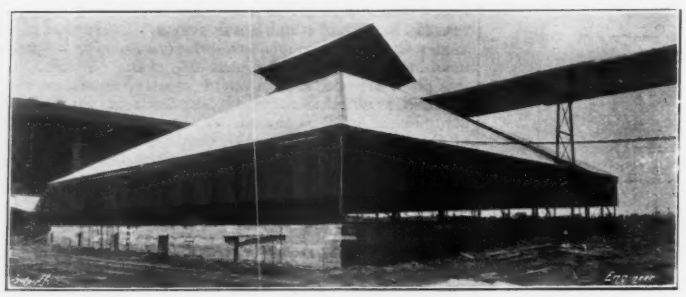


Fig. 6—THE CLINKER STORAGE BUILDING

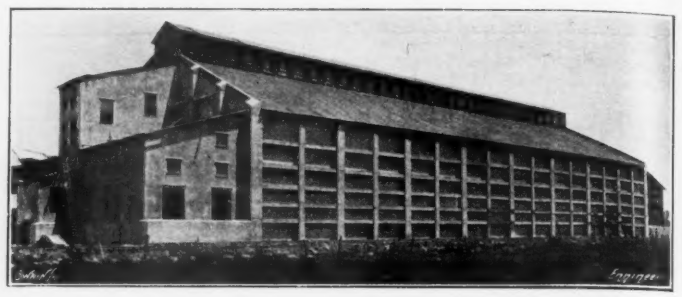


Fig. 7—THE CEMENT STOCK HOUSE

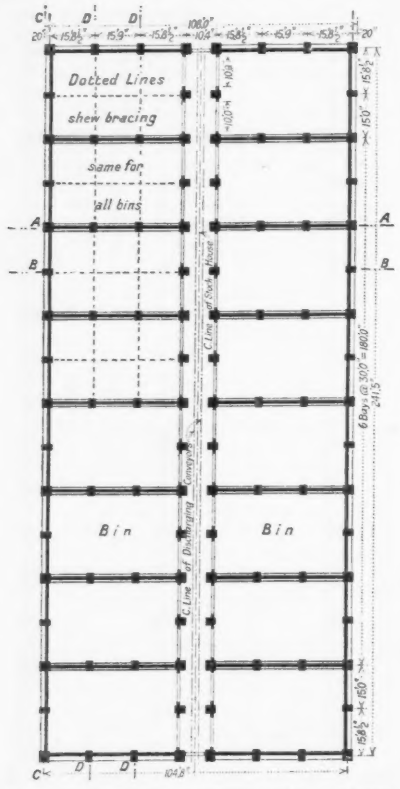


Fig. 8—PLAN OF THE CEMENT STOCK HOUSE

30ft. from the front of the kiln it becomes subjected to a temperature of about 3000 deg. Fah., and finally turns to clinker about 10ft. from the discharge end. The coal to provide the heat is blown into the lower end of the kiln at a pressure of 6 oz. per square inch. The ignition takes place immediately. From each kiln the clinker falls into a pit, whence it is taken by a bucket conveyor to its corresponding clinker cooler, one of which is provided for each kiln. Each cooler is 7ft. 6in. in diameter, 32ft. high, and has a cooling tower up the centre, fed by a 16in. cool air blast. It will be noticed on the engravings—Fig. 4—that these coolers are almost entirely outside of the building. On reaching the bottom of the cooler the clinker has been reduced in temperature to that of the outside air.

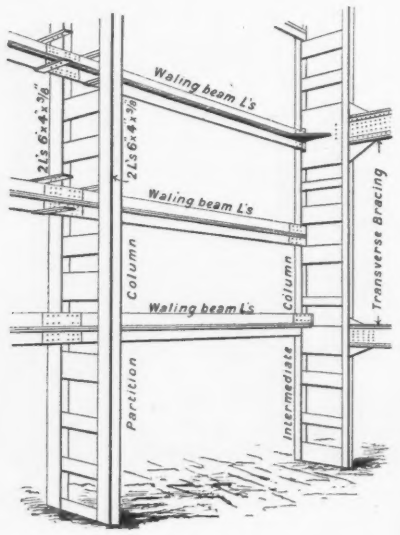


Fig. 9

A special safeguard against accident has been provided in the erection of a large clinker storage, with a capacity of clinker sufficient for 75,000 barrels of finished product—see Fig. 16. Ordinarily a supply of clinker is kept in this building. However, if desired the burnt product may be taken directly to the grinding department. In either case belt conveyors are used, these being arranged so that any of the kominor machines may be worked on the clinker, and similarly any of the tube mills. Having passed the latter, the cement is finished and ready for disposal.

Mention has already been made of the fact that manual labour has been reduced to a minimum throughout the plant. After leaving the stone house, fifteen men are required to complete the operation to this stage. So the plant is intended to be run by twenty men per shift in the actual manufacturing process. This, of course, is exclusive of the quarry men, shippers, repair men, dock hands and clerks.

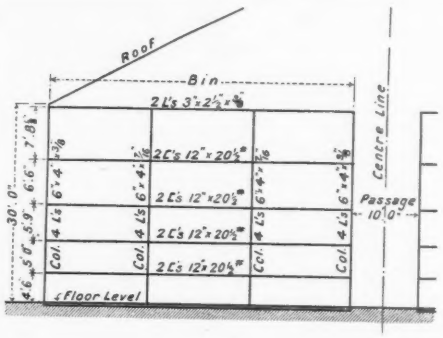


Fig. 10

The cement, on leaving the tube mills, is brought by a screw conveyor to a belt conveyor leading to the top of the cement store or stock house, as it is called—see Fig. 7—where in turn a screw conveyor runs the whole length of the building, and is able to place the cement in any of the sixteen bins into which the building is divided. The stock house gives an immense reserve supply, holding when full 320,000 barrels of cement. From the bins the cement is taken as required by two screw conveyors operating in tunnels under the centre of the floor to the packing house at either end of the stock house. In each packing house is a battery of hoppers receiving their supply from conveyors connected with those last mentioned, which enables the bagging to proceed rapidly. The sidings along either end of the packing houses furnish a convenient means of access to the cars. It is quite unusual to have such a storage capacity, but the Vulcan Company has adopted it as its policy in its American mills to keep a heavy stock for the double purpose of ensuring perfect seasoning in bulk and enabling it to ship any order on the shortest notice.

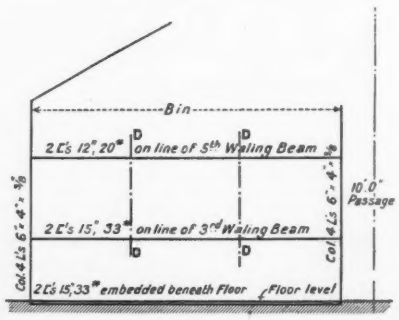


Fig. 11

The engraving Fig. 5 shows the design of the office. The building is entirely of concrete. The interior is plastered with cement. All floors are of "dolomenT." Hardwood ornamentation has been used throughout, and finished in the natural colour of the wood. Hot water heating, electric light, and even a shower bath make the building attractive and comfortable for the office staff. The interior is divided by a central hall, on one side of which are the executive offices, the other containing very complete chemical and physical laboratories. The time-keeper's and paymaster's department at the rear overlooks the entrance where all the workpeople are required to register their coming and going on time clocks.

The peculiar design of the pyramid-shaped clinker-storage building—Fig. 6—makes it worthy of description. The floor is of concrete, undermined by three transverse and one side tunnels, through which, by means of conveyors of the belt type, the clinker may be drawn from the building. The superstructure of steel has a very steep roof, with provision for ventilation on all sides. The apex of the roof is supported by a tower standing in the middle of the floor. A belt conveyor leads to the centre of the tower, and delivers the clinker to a spout, which may be revolved to discharge the clinker in any part of the building. Adjacent to the kiln building is a cross wall 5ft. high, to serve as a retaining wall for the clinker

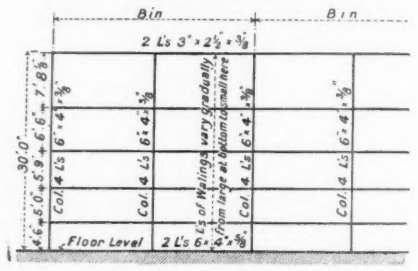


Fig. 12

pile, and to provide for the conveyors taking the clinker to or from the building.

As regards the stock house, it is difficult even with the aid of photographs and plans to describe this unusual building in such a way that its strength and massiveness may be realised. The building is, strictly speaking, of reinforced concrete, but the reinforcing is unusual from the fact of its being self-sustaining. Several reasons are given for the type of design selected, namely, a heavy riveted reinforcement—the heavy stresses to be provided for throughout in shear, bending, and tension; the unskilled labour available; and the necessity of conducting concrete operations during an unfavourable season, the winter. The arrangement adopted afforded the combined advantages of definite immovable placement of the steel and the elimination of a large amount of scaffolding otherwise necessary to support and brace the forms for the concrete.

It will be seen by referring to the plan of the building seen in Fig. 11, and to a larger scale in Fig. 8, that there is a central passage of about 10ft. width running lengthwise of the building. The side bays thus formed are divided by partition walls to make eight rooms or bins on each side. These bins, 35ft. deep, may be filled with cement in any convenient way, a full bin being adjacent to one that is empty. If necessary the central passage may also be filled. From these conditions it will be seen that the partition walls will be subjected to the same amount of loading from either side, while the outside walls must always have their load from one direction. The walls along the central passage have the same conditions of stress as the outer walls, since the passage will never be filled until after all the bins are full, and it must be emptied before any of the bins can be reached. These loading conditions resulted in the partition walls being designed of a section symmetrical about the central vertical plane, while all other walls are of unsymmetrical section.

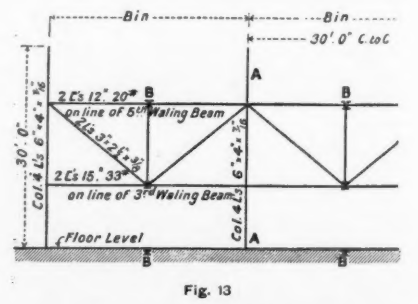


Fig. 13

The general arrangement places the partition walls at 30ft. centres.

The foundations are of 1:3:5 concrete, sufficiently large in dimension to distribute the loads on a stiff blue clay foundation 6ft. below the natural surface of the ground. Details of the steel reinforcement are given in the sketches—Figs. 9, 10, 11, 12 and 13. The bents are tied together both transversely and longitudinally of the building as indicated, the braces in the interior of the bins being left exposed. The whole is securely riveted together. Being exposed to the downward thrust of the cement, and possible bridging of it, the longitudinal bracing has diagonals introduced in it to care for the vertical stresses. It will thus be seen that the vertical elements of the main reinforcing consist of a series of posts 15ft. centres lengthwise of the building, tied transversely and longitudinally. The outer posts form the support for the steel roof trusses, 15ft. centre to centre. To the main vertical elements is attached a series of horizontal waling beams to provide for the horizontal stresses set up by the cement. The general position of these may be seen by referring to the engraving showing the exterior of the building—Fig. 7—the panelling showing the main members of the structure both vertically and horizontally. The first walings are at the floor, the next 4ft. 6in. above this, the spacing gradually increasing until the sixth waling near the eave is 7ft. 8in. above its neighbour. The gable walls are carried up above the roof line, and have one additional waling. All other walls stop at the level of the eaves.

The steel skeleton was manufactured in the usual way, except that where diagonal latticing would ordinarily be used, tie plates were substituted to join the component pieces of long members. Fig. 9 shows this departure in a pair of the columns in course of erection. Every column consists of four angles, for partition walls 6in. × 4in. × $\frac{7}{16}$in., and in all others 6in. × 4in. × $\frac{5}{8}$in. They are arranged in pairs with the longer legs outstanding. The partition columns have the short legs turned outwards, while in all other columns the inner pair stand the same way as the outer pair, that is, the short legs look towards the outside of the bin.

The heavy reinforcement of the waling beams in the partition walls consists of two 12in. channels at 20½ lb. per foot placed with flanges turned inwards. These channels are riveted to the posts, and are tied together at intervals with bolts. In this instance these walings are not really reinforced concrete beams, but are steel beams concrete filled. The reinforcement of all the other beams consists of two angles 6in. × 4in. × $\frac{5}{8}$in. in the lowest, decreasing to 3in. × 2½in. × $\frac{5}{8}$in. for the topmost waling.

The walls themselves are 10in. in thickness in all except the gable, where they are 11in., and form slabs to resist the cement pressures spanning the distance between the horizontal waling beams. The slab reinforcement, like the columns and walings, is symmetrical in the partitions and unsymmetrical for all the other walls. In the partition walls the slabs contain seven $\frac{3}{4}$in. rounds per panel on each side of the slab, extending vertically from bottom to top of the walls. For the other walls the reinforcement near the outer face is eight $\frac{3}{4}$in. rods continuous from top to bottom. For reverse stresses from continuous beam action these slabs are reinforced at each waling beam with eight rods per panel, $\frac{1}{4}$in. diameter and 3¼ft. long.

The principal reinforcement of the main members above described is supplemented by $\frac{3}{4}$in. rods wound around the columns every 18in. vertically. The waling beams of the outer walls have, in addition to the heavy angles already mentioned, round rods placed as follows during the concreting:—For reverse reinforcements at the supports, four $\frac{3}{4}$in. rods, 6ft. long, placed near the inner face of the wall at the column; and binding stirrups for web reinforcement and bonding of angles to the concrete. The partition columns are finished 24in. by 40in. All others are 40in. by 45in., in every case of uniform size for the whole height. The thickness of concrete outside the heavy metal is 1¼in.

The cement pressure in the bins is calculated from the following assumptions:—Cement, 100 lb. per cubic foot; angle of repose of cement, constant at 15 deg.; coefficient of friction between cement and plain walls, 0.55. Permissible stresses used were:—Concrete, compression, 800 lb. per square inch; shear in concrete, 70 lb. per square inch; steel in tension, 18,000 lb. per square inch; and ratio of moduli at 12.

The concrete for the superstructure was made 1:2:4, the largest size of stone being $\frac{1}{4}$in. The steelwork was left unpainted wherever embedded. During erection the columns and bracing were first set up. After the completion of the concreting the roof trusses were erected. The roof has steel purlins arranged in the usual manner, sheeted with plank and covered with a roofing composition according to the Barrett specification. The principal quantities of the reinforced concrete work of the stock house building are:—Concrete, exclusive of floors, 3570 cubic yards; riveted reinforcing, exclusive of roof, 510 tons; round rods, 103 tons.

This plant is controlled by interests which operate largely in the United States. The staff in charge have grown up with the company and graduated from the older plants. The sales department, of which Mr. W. H. Ford is in charge, in Canada has its office in the Bank of Ottawa Building, Montreal. Mr. S. R. Preston, who had the general design and arrangement of the plant in charge, is now managing the manufacturing operations. To these two gentlemen the writer is indebted for the information in this article.

SILICO-MANGANESE and silico-chrome in medium carbons have had considerable popularity abroad for springs and for gears for motor cars. They are also made in low carbons. Chrome steels in high carbons are much used for balls and ball races. Tungsten steels of special analysis are universally used for making magneto magnets.

THE ROYAL COMMISSION ON CANALS AND WATERWAYS.

No. XVII.*

THE FINAL REPORT (ENGLAND, WALES AND SCOTLAND).

THE final report of the Royal Commission on the Canals and Inland Navigations of England, Wales and Scotland was issued on Tuesday, Dec. 28th, as a parliamentary paper (Cd. 4979). It is announced that the report of the Commission on Irish waterways will be issued at a later date, the delay being due, we believe, to the wish of the Commissioners to have the report of the Viceregal Commission on Irish Railways before them when preparing their own report on the canals.

The Royal Commission on the Canals and Inland Navigation of the United Kingdom was appointed on the 5th March, 1906 to report on:—

(1) Their present condition and financial position;

(2) The causes which have operated to prevent the carrying out of improvements by private enterprise, and whether such causes are removable by legislation;

(3) Facilities, improvements and extensions desirable in order to complete a system of through communication by water between centres of commercial, industrial or agricultural importance, and between such centres and the sea;

(4) The prospect of benefit to the trade of the country compatible with a reasonable return on the probable cost; and

(5) The expediency of canals being made or acquired by public bodies or trusts, and the methods by which funds for the purpose could be obtained and secured; and what should be the system of control and management of such bodies or trusts.

The chairman of the Commission is Lord Shuttleworth, and the members are Lord Brassey, Lord Farrer, Sir John Dorrington, Sir John Brunner, M.P., the Rt. Hon. Russell Rea, M.P., who was chairman of the Committee on the Port of London Bill, 1908, Sir W. J. Crossley, M.P., formerly a director of

THE "CROSS."

the Manchester Ship Canal, Sir John Wilson, Sir Francis Hopwood, K.C.M.G., K.C.B., Permanent Under-Secretary of State for the Colonies, Mr. J. F. Remnant, M.P., a late member of the L.C.C. and chairman of S. Allsopp and Sons, Limited; Mr. Snowden, M.P., Mr. H. Vivian, M.P., Mr. L. A. Waldron, M.P., chairman of the Grand Canal Company, Ireland; Mr. R. C. H. Davison, M. Inst. C.E, formerly engineer to the Royal Commission on the Port of London (1905); Mr. J. P. Griffith, M. Inst. C.E., engineer to the Dublin Port and Docks Board; Dr. A. T. Herbertson, Reader in Geography in the University of Oxford; Mr. J. C. Inglis, president of the Institution of Civil Engineers and general manager of the Great Western Railway; Mr. H. F. Killick, director of the Leeds and Liverpool Canal Company; and Mr. M. T. Minch, vice-chairman of the Kildare C.C. Lord Kenyon, one of the original members, resigned his seat on the Commission in 1908 on his election to the Board of the London and North-Western Railway Company. Mr. W. B. Duffield is the secretary to the Commission, and Mr. R. B. Dunwoody, A.M. Inst. C.E., engineer and assistant secretary.

The Commission have held 106 sittings, 88 of which have been for the taking of the evidence of 266 witnesses, much of which has been summarised in previous articles of this series. There have also been numerous meetings of special committees, and the members of the Commission have made repeated visits to canals and waterways in many parts of the United Kingdom and on the Continent. The report of Mr. W. H. Lindley, the assistant-Commissioner, on the Waterways of the Continent, has already been dealt with in these pages.† The Commission have received reports from Sir John Wolfe-Barry and Partners on the cost of improving certain main canal routes, and the engineer to the Commission, Mr. Dunwoody, has made special investigation into the question of the water supply for enlarged canals and other engineering matters. His reports, with that of Sir John Wolfe-Barry and Partners and other appendices, will fill three volumes yet to be published. The Majority Report and all the separate minority reports are unanimous in bearing testimony to the excellent services rendered by Mr. Dunwoody, and the thanks of the Commission are also rendered to the Secretary, Mr. Duffield, and the others who have given valuable assistance.

* No. XVI. appeared December 24th.

† THE ENGINEER, October 29th and November 12th, 1909.

THE MAJORITY REPORT.

The Majority Report is a document of 189 pages, and is signed by the chairman and fifteen other members, five of whom, however, make sweeping reservations. With these reservations and the three separate minority reports we propose to deal in another article. In our leading article in this issue we indicate the tenour of the views of those members who are opposed to the recommendations contained in the Majority Report.

Historical sketch.—The first part of the report consists of an historical sketch which forms an admirable *résumé* of the history of canals and inland waterways in this country. Much of the information contained in this section has already appeared in our earlier articles, and we shall only refer to the general remarks and conclusions of the Commissioners. The report points out that "the largest part of the existing canal system had been completed by the end of the eighteenth century, and the whole of it, with the exception of the Manchester Ship Canal and a few short cuts or arms, was completed before 1830, the year of the opening of the Liverpool and Manchester Railway. It is important to observe that in England and Wales practically all the artificial waterways were made by private enterprise, without any financial assistance from the Government, and, except with regard to some of the waterways in the eastern counties, primarily intended for arterial drainage, without any assistance from local rates. The same statement would by no means be true either of Scotland or Ireland. In Scotland the Caledonian Canal was constructed and improved entirely by means of grants made by Parliament, and the Crinan Canal was completed by means of similar grants. . . . Many, though by no means all, of the English canals were, in their earlier days, successful financially to a high degree, and their shares stood at a considerable premium."

Figures are quoted which show that the net revenue derived at this period from many of the waterways must have been considerable in proportion to the capital cost. This flourishing period in the history of waterways came to a gradual end as the railway era advanced, and everywhere the proportion of long-distance traffic to local traffic by water has become small. The waterways, on the whole, have had no share in the enormous increase of internal transport business which had taken place between the middle of the nineteenth century and the present time. On the other hand, the cost of transport to and from the ports had become of the greatest importance to inland manufacturers by reason of the immense increase in the imports of raw material for manufacturing purposes. As an example;—"To Birmingham and the surrounding districts and to other inland centres, the raw material of iron is of the highest importance. In the year 1892 the total pig iron produced in the United Kingdom from British ores was 4,041,178 tons, and that from foreign ores was 2,668,077 tons. In the year 1907, 5,126,949 tons were produced from British ores and 4,987,332 tons from foreign ores. . . . Manufacturers are tempted to move, and in some cases actually have moved, their works to places where, as in South Wales, Northumberland or Lancashire, coal is found in close proximity to seaports."

On the question of the early rivalry between canals and railways the report says:—"When the era of railways commenced the waterways had attained to the highest point of their prosperity. The canal companies had taken full advantage of the great superiority which they had over road traction, were charging high tolls to the public and conveyed a great traffic for long as well as short distances. As the development of the railway system advanced, it became evident that this position of advantage could not be maintained." Parliament showed its desire to preserve the competition of waterways with railways, and to give equal facilities to both competitors for traffic, but the canal companies took very small advantage of the powers to become carriers and to effect amalgamations with each other, although they did in many cases reduce their tolls, which in some instances were lowered to one-seventh of their former amount. In fear of the power of the railways to destroy their profits, in many cases they opposed Railway Bills in order to arrive at some arrangement in the interests of their shareholders. The result frequently was an actual or virtual transference of the waterway into the hands of the railway company. In other cases the canal companies took powers to convert their own waterways into railways. In the year 1846 Parliament allowed seventeen canals, of a total length of 774 miles, to come wholly or partially under railway control, and practically a third part of the waterway mileage was so transferred in the years 1845-7.

The multiplicity of authorities and the consequent impediments to through traffic is admitted on all hands. The report cites many instances of this, among them the fact that traffic despatched by canal from Birmingham to the Port of London has to pass over no less than seven waterways owned by different authorities. "Assuming that the waterways remain as they are in condition and administration, it is difficult to see that Parliament could do much more than it has already done by . . . . legislation to facilitate long-distance traffic, or by rail and water combined," for the English canal companies have never attempted to establish a clearing-house system under the powers given by the Act of 1888. Apparently they have

not had sufficient energy or spirit of co-operation to do this, or else the relative smallness of through traffic has not made it seem worth the trouble. The canal companies, who themselves acted as carriers, at one time wished to establish a clearing-house; but the other non carrying companies were indifferent, and would not co-operate.

The present condition of waterways in Great Britain.—The second part of the report deals with the present condition of the inland navigations, dividing them for the purpose of classification into:—

Canals	1927	miles.
Canalised rivers...	1313	,,
Open rivers...	813	,,
	4053	,,

The canalised waterways of England and Wales divide themselves into two nearly equal divisions—those with locks under 14ft. wide, or narrow canals, and those with locks over 14ft., or barge canals. Details are given of the present condition of the principal waterways and canals as regards traffic and in other respects. From them it appears that the commercial traffic on the Thames above Staines has become a very insignificant quantity, and on the Severn navigation, "notwithstanding the consider able sums which have been spent and the poor results achieved, the traffic has fallen off." The Trent Navigation Company have, up to the year 1906, spent £150,000 on river improvements, with the result that they do not pay any dividend on either their preference or their ordinary stock. As to the Yorkshire Ouse, "the profits on the traffic itself are small, . . . and the existing work on the river appears to be hardly sufficient to maintain it even in its present condition." As to the Bedford Ouse and the Nene, the account given in the report of these rivers may be summarised by the word deplorable. Coming to the canals and minor rivers, the Commissioners find that the Great Western Railway Company as owner performs, in so far as is practicable, its obligations in maintaining the Kennet and Avon Canal, on the score of which it has been so much blamed in the past. The neighbouring independent Wilts and Berks Canal is derelict, and the Thames and Severn Canal is practically so, in spite of strenuous efforts to revive its traffic; but, in the words of the report, "it is obviously difficult to revive a through traffic by water which has fallen into disuse."

The Oxford, Coventry, and Ashley canals are passed over with brief comment, and the Grand Junction, one of the most important of English canals, is stated to be well maintained and comes in for considerable praise. The Birmingham Canal, controlled by the London and North-Western Railway, comprising nearly 159 miles of narrow waterways, is reported to be generally in good order, and, in spite of complaints, the railway company "appear not to have failed to do their duty in dredging." The Shropshire Union canals are railway controlled, and "no serious complaints" concerning them were made to the Commission; indeed, one witness described them as the best managed in England. The River Dee Conservancy has an annual excess of expenditure over receipts, but the report states that "the question of the improvement of the Dee, both in the interests of the adjacent districts and in that of the inland navigation by the Shropshire Union canals, appears to us to deserve careful consideration." The North Staffordshire Railway Company is stated to maintain the Trent and Mersey Canal in very fair condition. The River Weaver Navigation is well maintained, but the cost of maintenance is heavy, amounting to £574 per mile. The Macclesfield Canal and others belonging to the Great Central Railway Company are in a fair condition, and the Midland Railway canals escape without censure. The abandonment of the Butterley tunnel on the Cromford Canal, proposed by the Midland Railway Company, is recommended in the report.* The only railway company owning canals in any way censured in the report is the Great Northern. "The company appear to do nothing to improve (their) canals, and to content themselves with merely providing bare repairs and maintenance. They confine themselves, in short, to the performance of their legal obligations in a more or less adequate fashion."

Coming to the northern canals, the Leeds and Liverpool seems to be well maintained; large sums have been expended upon it in recent years, and the maintenance charge has averaged £150 per mile for some years. The lack of adequate water supply stands in the way of further improvement. The traffic on the Bridgewater Canal has decreased since the construction of the Manchester Ship Canal, but the navigation is kept in good order. The Huddersfield Canal, belonging to the London and North-Western Railway Company, is kept up at a loss, but the Aire and Calder Navigation "carries a very large and increasing traffic. This success seems to be due to its natural position of advantage, energetically utilised by its owners in making costly improvements, and in themselves taking a vigorous part in the carrying trade." The Aire and Calder appears to be one of the few successful inland navigations in the country. As to the waterways of the eastern counties, the report states that the county is eminently suited to purposes of navigation. "It is also the part of England where authorities controlling waterways are the most chaotically multiplied, and when least is done by art to make use of the facilities offered by nature."

The Commissioners summarise their observations on the English and Welsh waterways in the following words:—"The foregoing review of the actual material condition of the English waterways at the present time shows the impediments thrown in the way of through or long-distance traffic by differences in sectional areas, size of locks, depth of channel, and general condition, by divided ownership of different waterways, and by the deteriorating condition and insufficient depth of channel in some sections of through routes. It is never easy to predict whether a cargo loaded at one point may not prove too heavy to be taken through to a distant point."

* *Vide* THE ENGINEER, December 13th, 1907.

Coming to Scotch canals, the most important is the Forth and Clyde, now the property of the Caledonian Railway Company, which spends £12,000 a year in maintaining it. Since 1867, when it passed to the present owners, the traffic has decreased from three millions to one million tons per annum, notwithstanding energetic efforts on the part of the railway company to foster its trade. Of the other Scotch navigations, the Caledonian Ship Canal is maintained at an annual loss and the Crinan Canal at a small profit.

Financial position and traffic.—Part III. of the report deals with the financial position and amount and character of traffic on the existing canals. In this connection it must be noted that the tonnage of a cargo conveyed over more than one canal is counted in the returns to the Board of Trade of each canal over which it passes on a single journey. Thus the actual total traffic must be considerably less than the apparent.

While the total tonnage carried on the waterways remained practically stationary in amount between 1888 and 1905, the goods and mineral traffic on the railways increased from 281,747,439 tons in 1888 to 461,139,023 tons in 1905—an increase of 64 per cent. The Great Western Railway mineral and goods traffic in 1905 exceeded the total apparent traffic of the canals and waterways—39,498,926 tons—by over three millions of tons, and the figures of the London and North-Western Railway are still larger. As noted above, a part of the canal traffic is counted more than once. Twenty-one millions of tons of the canal traffic was taken by a small proportion of the canals—982 miles out of 5085 miles. The average length of haul of water-borne traffic is difficult to determine, owing to the absence of returns; but the report contains particulars for certain canals, from which it appears that the average is 17.4 miles on a length of 814 miles for which figures are available. "Almost the whole of the long-distance traffic is carried by railways or by the sea; canal companies only live in most cases by means of local or short-distance traffic, eked out in some cases by rents from house property, and in many cases they would gain rather than lose, as things now stand, by not having to maintain some portions of their waterways." To some extent the diminution of long-distance traffic on the waterways is due to the competition of coasting traffic, although in the main it must, of course, be accounted for by railway competition. The coal carried to London by canal is only about 0.10 per cent. of the total of about 15½ millions of tons annually. The figures for 1905 are:—

	Tons.
Rail-borne coal to London	7,137,473
Sea-borne coal to London	8,494,232
Canal-borne coal to London	18,681

Since 1880 the sea-borne tonnage has more than doubled, while the rail tonnage has increased by less than one million tons. Not only are the canals competing against the railway, but in many industrial districts they have now to face the competition of the roads.

The total revenue derived from canal and waterway tolls in the United Kingdom in 1905 was £921,006, as against £681,231 spent on maintenance and management. The net revenue derived from freight by those canal companies who themselves carry was £167,213. The tonnage conveyed per mile on the railway canals is slightly greater than on the independent waterways. The total figures for 1905, omitting certain mileage for which statistics are wanting, are:—

	Tonnage.	Mileage.
Independent waterways...	20,434,411	... 1923
Railway controlled or owned waterways	13,702,356	... 1225

The total paid-up capital of the independent waterways of the United Kingdom, excluding the Manchester Ship Canal concerns, is nearly 19½ millions, and in most instances the dividends earned have in recent years decreased, and in some cases vanished altogether. Statistics as to the capital of, and dividends paid by, railway owned and controlled canals are difficult to summarise owing to their being so much mixed up with the finances of the railways.

The causes of decline.—Part IV. of the report deals with the causes which have operated to prevent the carrying out of improvements by private enterprise. The inquiries of the Commission as to the practicability of raising funds by private enterprise for the improvement of waterways have been met with the general reply that it is not possible, the reason usually given being that there is a complete want of faith in the future of canals on the part of the investing public. In the opinion of the Commission the causes of this want of faith are:—

"(1) The haphazard system by which canals were originally constructed, without any uniformity of gauge or locks, and their ownership by so many different authorities and companies; and the arrest of development and amalgamation in consequence of the advent of railways.

"(2) The situation which has been caused by the transfer of many important sections of the waterways to railway companies.

"(3) The kind of paralysis or arrest of development which has resulted from all these causes throughout the whole canal system."

As to the effect of railway control, the report continues:—"It would not, we think, be just to say that, in all or even in most cases, railway companies have failed to discharge the statutory obligations placed upon them . . . to maintain their canals . . . in good working condition. It cannot, we think, be said, broadly speaking, that the canals belonging to railway companies are, at present, worse maintained than are those which are controlled by local authorities, or those which belong to private companies. . . . It is possible that certain canals would not have been maintained at all had they not been in the hands of wealthy railway companies," and many instances are adduced to show the actual benefits derived from the fact of railway ownership. And again—"In most cases we can well believe that, as some of their representatives informed us, they—the railway companies—would not object to be rid of the canals if they could be sure that they would not be used as subsidised instruments of competition against them. It is not just to say, as some have said, that railway companies—except, perhaps, in a few instances—acquired canals in order to strangle them."

On the question of the effect of competition on rates the matter is well summed up in the following words:—"From the point of view of the merchant, the existence of an independent waterway is of value as keeping down railway rates, even if it does not carry much traffic." On the other hand, the Commissioners are convinced "that private enterprise cannot be expected to take the improvement of canals in hand, because, as things now stand, there is no prospect of adequate remuneration, except, perhaps, in a very few cases." Traders will always send large classes of goods by railway, but there are other classes of goods which they would, in the opinion of the Commissioners, prefer to send or receive by water if there were really a marked superiority of cheapness in rate of transport, increased rapidity of transit, punctuality, and regularity of service, as well as adequate arrangements for collection and delivery.

The results of the existing condition of waterways.—Part V., after discussing the relative advantages and economies of rail and water transport, goes on to point out that the dimensions of few English inland water routes allow a cargo of more than 60 tons to be taken in a single boat for any long distance, while on most of the canals only boats holding 20 to 30 tons can be used. The obvious economy of dealing with larger units of load is discussed, and the tendency of certain industries to migrate from the Midlands to the seaboard is illustrated by concrete examples. In connection with this last-named industrial tendency, the report contains the statement:—"It may fairly be held that the State is concerned in ensuring to its citizens by its own action, if private enterprise fails to accomplish this end, the best and most economic modes of transport, so that industry and commerce may be carried on as effectively as possible." The Commissioners have apparently come to the conclusion that private enterprise has failed to secure the requisite degree of efficiency and economy in inland transport, and, in consequence, "if the balance as between railway and waterway transport is to be rectified, and if traffic is to be suitably distributed between them, it is necessary that the main water routes should be so reconstructed or improved as to allow larger cargoes to be conveyed for the same distance by less labour in shorter time than present conditions permit." This, says the report, is the remedy which has been successfully applied in other countries.

The remaining sections of the report deal with the selection of the waterways for proposed improvement, and discuss the probable cost of improvement and the increase of traffic expected as a result of the improvements. With these matters, as well as the recommendations concerning Scottish canals, we shall deal in a future article. For the purpose of illustrating the proposed improvement of "The Cross" waterways, which we refer to briefly in our leading article, we reproduce on page 683 a sketch map, indicating in outline the selected routes.

THE THEORY OF SUPERHEATING.

THE use of superheated steam is, beyond question, extending. The principle is, so to speak, forcing itself into favour because of its intrinsic merit. It would appear, however, that the theory of superheating is very imperfectly understood, because it has received small consideration. The use of superheated steam dates back to a period when theory was of little account. In so far as saving in coal was concerned, it invariably gave excellent results; and its use was in all cases given up with regret by those who had tried it. Its lack of permanence was the result invariably of mechanical difficulties; never because it did not save fuel. In recent years it has been taken up and tried simply on its merits, without much regard being paid to reasons why. It has been assumed that nothing could be gained by having a theory; nothing lost by the lack of one. Probably this is to a large degree true; and yet it would seem that a theory would possess interest for a great many engineers, and that a knowledge of one might prove on occasion useful.

As a matter of fact, there are three general reasons given for the economy secured by superheating steam between the boiler and the engine. The first is that it prevents cylinder condensation, and so gets rid of the "missing quantity." The second is that by superheating steam its volume is greatly augmented; and the third is a combination of both. A fourth reason deserves mention here. It is that superheated steam is much more "lively" than saturated steam. It flows more rapidly through ports and passages, and as one result back pressure is reduced. The late D. K. Clark found in his experiments that locomotives with outside cylinders, other things being equal, always had a sensibly higher back pressure than had those with inside cylinders, simply because the exhaust steam from the former was more sluggish than that from the latter. In the present day drivers remark that, whether fuel is saved or not, at all events, there is "more life in the engine." It will be seen that it is not easy to eliminate the consideration of the question of activity, particularly from triple-expansion engines, in which the distances to be traversed are considerable, and the passages are crooked and somewhat contracted.

If we take up the anti-condensation theory we find it very difficult to formulate any definite figures, because so little has been determined as to the nature and causes of initial condensation. Its amount varies in a way that really defies all calculations; and the most we can do is to provide a sufficiently high temperature to prevent condensation. So far, practice in this direction has been pure empiricism. The general rule is to make the steam as hot as it can be made without doing mischief, either

to the superheater or the engine. Much depends on the nature of the oil used as a lubricant, and the rate at which the superheat departs. In many instances a superheat of 250 deg. Fah. has, it is said, disappeared entirely before the piston has made one fourth of its stroke, and it is worthy of notice that it is not easy to detect the difference between diagrams with and without superheat. The broad fact is that, be the diagrams what they may, less feed water is used per horse-power with than without superheat.

The theory of superheating on this basis is that each pound of steam takes in an additional quantity of heat, depending for its amount on the temperature and the specific heat of the steam. Thus, for example, let us suppose that an engine is supplied with 15 lb. of steam per horse-power per hour, the pressure to be 150 lb. absolute, and the feed-water temperature 100 deg. The total heat supplied to each pound by the coal will be, in round numbers, 1123 deg., or to be accurate B.Th.Us., and $1123 \times 15 = 16845$ as the quantity from which to get as much work as we can. The temperature of 150 lb. is 358 deg. Fah. If now we superheat it by 200 deg. Fah., we have a temperature of 558 deg. Fah. The quantity of added thermal units will be found by multiplying 15 lb. into the specific heat of the steam; what the specific heat of gaseous steam is has not yet been conclusively determined. Under constant pressure—the condition with which we have to deal—Regnault found it to be .475. There is reason, however, to believe that it is higher, and we shall not be far wrong if we take it in round numbers as .500. We have then $200 \times .5 \times 15 = 1500$ units, and the total stands at 18,345. It will be seen that the expenditure of heat in raising the tempera ture of the steam is very small as compared with that required to make it. It amounts to only about 9 per cent. But the loss by initial condensation may amount very easily to 30 per cent. If this is avoided by superheating it is no wonder that a marked economy follows the use of superheated steam.

As we have said, it is impossible to predicate in any case what the saving will be, because of the lack of the necessary data. There, however, is the theory as far as it goes. A small quantity of heat expended in raising the temperature of the steam will obviate the phenomena, whatever they may be, which bring about the missing quantity; and it is worth notice that this condition holds good whether the missing quantity is explained in the normal way, or by valve leakage as supported by Messrs. Callendar and Nicolson.

We may now proceed to the consideration of the second theory, which is that the saving effected is mainly due to the augmentation of the steam volume, and a general all-round improvement in the quality of the steam. This may be termed the physical theory, and it possesses several ramifications. Thus, cylinder condensation is not prevented by the augmented temperature of the metal, but by the circumstance that dry steam parts with its heat much more slowly to metal than does wet steam. The experiments of Siemens, and Fairbairn and Tate go to show that at first the rate of increase of volume is very rapid—as much as five times that of air. The rate tapers off, however. Thus with 95 lb. steam the rate of expansion up to 331 deg. was nearly three times that of air, and for the next 25 deg. only one-sixth greater. Rankine held that ordinary steam became gaseous when superheated 40 deg. Fah. D. K. Clark held that this result could be obtained when the superheat lay anywhere between 10 deg. and 20 deg. He writes:—"It is thought that the rapidity of expansion by heat near the boiling point is to be accounted for by the supposed insensible moisture of steam in the saturated condition, as generated from water, being evaporated and contributing to increase the quantity of steam without raising the temperature. The argument is plausible; but it might be argued on the contrary that in the converse process of abstracting heat from superheated steam, the accelerated reduction of volume when it approaches the point of saturation is due to incipient condensation, which would be absurd." It does not appear, however, that the statement is really absurd at all. The total withdrawal of superheat ought to leave the steam in its original condition, and if it originally contained free water, that water would of necessity be found at the end of the operation, as there would be no heat available to maintain it as steam. Fairbairn wrote in 1860:—"Close to the saturation point we find a very high rate of expansion, but this rapidly declines as the steam superheats, and at no very great distance above it the rate of expansion nearly approaches that of a perfect gas. Thus, for instance, in experiment (6) where the point of maximum saturation was 174·92 deg., between this and 180 deg., the steam expanded at the mean rate of $\frac{1}{170}$, whereas air would have expanded $\frac{1}{854}$ only; but on continuing the superheating the coefficient was reduced between 180 deg. and 200 deg., from $\frac{1}{170}$ to $\frac{1}{537}$, and for air the coefficient would have been $\frac{1}{539}$, or almost exactly the same, and this rule holds good in every experiment; a high rate of expansion close to the saturation point diminishing rapidly to a close approximation to that of air."

It is not quite clear where Fairbairn got the coefficient $\frac{1}{534}$, but it is immaterial. It may be taken as proved that the rate at which steam expands while being superheated is not less than that of any permanent gas. Applying this to the case we have stated above, we have 15 lb. of steam at a pressure of 150 lb., and an absolute temperature of 819 deg. Fah. and a volume of 44.4 cubic feet. Adding 200 deg. Fah. superheat we have, according to Regnault's tables, an augmented volume of about one-sixth, or, say, 17 per cent. If, however, the steam was in the ordinary condition before it went into the superheater, it is probable that, according to Fairbairn and Tate, the increase in volume would be much larger. We shall not be far wrong, we think, if we assume that superheating steam by 200 deg. Fah. will augment its volume 20 per cent. How much heat will be expended in doing this depends on the specific heat of gaseous steam. It is evident that we have apparently a very important factor here. The augmentation of volume may be counted upon, and that, too, of perfectly dry steam which can lose a good deal of heat before condensation will take place. Nevertheless, it is frequently argued that the increased volume is a wholly negligible quantity, and is never found in the cylinder, a statement which can only be true if the whole of the superheat disappears as soon as the steam enters the clearance space. For the case we are considering it amounts to 1500 units per horse-power per hour. No one has the smallest knowledge of what becomes of it. Liquefaction due to the performance of work takes place with saturated steam because the steam loses latent heat. But is it not possible that when superheated steam is in the cylinder the action is that which occurs when a permanent gas does work? And the first loss is represented by drop in temperature and not by the sacrifice of latent, or it may be said structural, heat—that is, the heat expended in producing the highly unstable fluid known as saturated steam.

The third theory is, as we have said, a combination of the two views. Superheating augments the volume of the steam produced from the feed-water, and it raises the temperature of the cylinder and piston surfaces so high that initial condensation is prevented. We believe that this represents the facts better than either alternative theory taken alone. But none the less is it certain that some anomalies exist which have yet to be explained. One is the exceedingly small effect of superheating on indicator cards. Nominally, this means, of course, that the same average pressure is obtained with a less weight of superheated than saturated steam. But, so far as is known, the only difference in the cards seems to be a reduction to a small extent in back pressure. This can, of course, be explained by saying that superheat is quite ephemeral. The experiments which have so far been made as to the temperatures inside the cylinder are very imperfect. We do not refer to the cylinder walls, but to that of the steam, which is quite another matter. No doubt in many cases superheated steam is carried through considerable distances in badly clothed pipes, and the most that it can accomplish is effecting some reduction in the condensation which would otherwise go on in these pipes, the superheat never reaching the cylinder.

We have failed to find any record of detailed experiments made with really large engines to settle numerically the effect on the consumption of fuel, save those conducted by Isherwood, and recorded in "Experimental Researches in Steam Engineering," published as far back as 1865. They were made with paddle-wheel beam engines of great size; thus the s s. Adelaide had a single cylinder 50in. diameter and 12ft. stroke, driving paddle wheels 31ft. in diameter. Another ship, the Georgeanna, had a cylinder 44in. diameter, 11ft. stroke. The general result was a saving of over 20 per cent. secured by moderate superheating. This investigation was conducted with great care, and Isherwood's report is worth very careful perusal by engineers interested in superheating. We cannot better conclude this paper than with the following extracts from it:—"The very great increase of economic effect practically resulting from even such moderate degree of superheating as will just prevent condensation in the cylinder, can be easily understood, when it is considered that—supposing the condensed steam to be precipitated on the metallic surfaces and not suspended like a mist or fog in the steam remaining in vaporous form—this condensation counts twice against the fuel; once in the reduction of the power, and again in the quantity of heat which has to be imparted to these surfaces by the boiler steam to re-evaporate the water of condensation from them. In other words, all the steam condensed in the cylinder has to be twice evaporated, while no useful effect whatever is obtained from it. Practically, however, it appears that the whole of the steam condensed in the cylinder, due either to the production of power or the expansion *per se*, is not precipitated upon the metallic surfaces. The condensation due to these causes takes place uniformly throughout the whole mass of steam in the cylinder, and the portion which remains in the vaporous form is able to hold a certain weight of it in suspension, while the remainder must fall upon the surfaces. All the condensation, however, due to external radiation, and to the coldness of the interior metallic surfaces, after their exposure to the condenser temperature and action, must be deposited on those surfaces and re-evaporated by the heat of the boiler steam entering for the next stroke of the piston; consequently all such condensation certainly counts twice against fuel, while the previously described condensation, due to the production of power and to the expansion of the steam *per se*, may count only once or they may count in any proportion between once and twice against the fuel."

We have referred above to the smallness of the effect of superheating on indicator diagrams. Referring to his experiments with the s.s. Georgeanna, with various changes of superheating, Isherwood writes, "It will be seen that the expansion curve formed by the steam pressure in the cylinder after the closing of the cut-off valve, was almost identical with what it should be according to the simple law of Mariotte, that is to say, the pressures were inversely as the volumes, without regard to the variation of temperature. The same coincidence will be found in steam engines in good condition working without air leaks and saturated steam; and it is interesting to note the agreement in cases of extreme diversity in the kind and pressure of steam used, size of cylinder, and measure of expansion. It obtains whether the steam pressure be high or low, whether it be saturated, slightly superheated or greatly superheated, and whether the measure of expansion be great or small. Of course it is purely a coincidence, but being a constant one, it has its practical value for approximate results from boiler pressure when the indicator evidence is wanting."

DOCKYARD NOTES.

THE old Indefatigable, of the Apollo class, has been renamed Melpomene, in order to make way for the new cruiser Indefatigable.

IT appears to have originally been the Admiralty policy to make all these Dreadnought cruisers an "1" class, but since the latest has been called Lion, the idea seems to have been abandoned. On the whole, this is rather unfortunate. The idea, of course, commenced with the Pelorus class, every one of which was given a name beginning with "P." The idea was an extremely sensible one, and might with advantage have been carried much further, without going outside the classical list of ship names, and so upsetting the signal-books.

THE final plans of the new Argentine Dreadnoughts have now been passed. The ships will be called Rividavia and Moreno. They will be of 25,000 tons displacement, and carry twelve 12in., twelve 6in., and twelve 4in. The speed will be 22 knots. There will, it is said, be two funnels and two skeleton masts of the new American type. The whole of the twelve big guns will bear on either broadside. The contract is to contain a clause for the completion of the ships in eighteen months.

ORDERS have also been placed for twelve ocean-going destroyers of the same programme. These will be of about 900 tons and 32 knot speed. The contract for four has been placed in this country, four others in France and four in Germany. The contract for this country has been secured by Messrs. Cammell Laird.

THE Greek navy is about to be enriched by an armoured cruiser, presented to it in his will by a patriotic Greek millionaire. The advent of this cruiser has caused considerable heartburning in Turkey, and a vessel of equal power is projected for the Ottoman Empire. Early delivery is *sine quâ non*, and the contract is likely to go to that firm which undertakes to build a vessel in the shortest possible time!

IN this connection it is interesting to note that Germany is reported to have followed the Italian lead of laying down warships on the chance of securing a subsequent purchaser. Rumour has it that the well known firm of Schichau has a half-completed battleship waiting a possible purchaser. Like everything else having to do with shipbuilding in Germany, this rumour is, however, entirely unconfirmed.

THE status of existing naval engineer officers is now on the *tapis*. The question is, fortunately, being discussed with a complete absence of that heat which would have attended it a few years ago. It is now recognised by nearly everybody that directly the new lieutenants (E.) come into the service, all existing engineer officers must be placed on a somewhat similar footing. Any opposition to this that exists may be said to have been created by those, who, with the best will in the world, have agitated in this direction. If things are allowed to take their normal course, it may be taken for granted that no attempt will be made to try the important experiment of two types of engineer officers in the Navy.

WHETHER the new type of engineer officer will be better than the old one, is, to say the least of it, a very open question. The new scheme was primarily designed to overcome certain personal questions that had nothing whatever to do with naval efficiency, which, in consequence, were not really germane to the subject. We have neither wish nor intention to touch upon controversies of this nature. The only possible use of the British Navy is to secure the maximum of efficiency, regardless of anything else. This could probably have been fully secured by a concession to the requests of the existing engineer officers, except for the fact that the British Navy never is, and never will move, with the times. The new scheme may, therefore, be the best compromise and best solution of a very difficult question from the utilitarian standpoint. But whether it is the best from the practical standpoint remains to be proved.

IT is rumoured at Portsmouth that in order to increase the accommodation in the harbour extensive dredging operations are shortly to be undertaken, and that arrangements are to be made so that ships can be moored fore and aft, in order to prevent their swinging with the tide, and so increase their available accommodation. Spithead is theoretically demonstrated invincible about once a month, but for practical purposes it is a quite unsafe place for ships to lie at in war time.

IN connection with modern inventions, a correspondent from Constantinople writes to us to say that he has just discovered there a Turkish monitor, dating from the year 1870, or thereabouts, fitted with a couple of tripod masts practically identical with those that are fitted to the super-Dreadnoughts of to-day!

HOLLAND-AMERICA LINER NIEUW AMSTERDAM.—This large passenger steamer has been in the hands of her builders, Messrs. Harland and Wolff, Limited, Belfast, for the past few weeks, for certain alterations necessitated by the popularity of the vessel in the Holland-America Line. For instance, the bridge front on the awning deck has been extended, thus largely increasing the first-class dining saloon, &c. The saloon is now a magnificent apartment extending the whole width of the ship, and, with the addition of over 150 seats, has been made one of the largest and finest saloons on any vessel crossing the Atlantic. The alterations also provide extra promenading space on the bridge deck for games, &c. The necessary work having been carried out, the ship left Belfast on the 20th instant for Rotterdam, where in due course she will resume her sailings in the New York trade. The Nieuw Amsterdam is a vessel of over 17,000 tons, and was built by Harland and Wolff, Limited, at Belfast in 1906. She is the second largest of the Holland-America fleet, the majority of which have been built by Harland and Wolff, who constructed the Rotterdam—23,980 tons—for that company last year.

RECENT IMPROVEMENTS AT SCARBOROUGH HARBOUR.

THE town of Scarborough is an exception to the rule that industry and pleasure cannot thrive side by side, and its picturesque and busy harbour lying snugly under the Castle hill and cliffs is not one of the least attractions of the famous watering place.

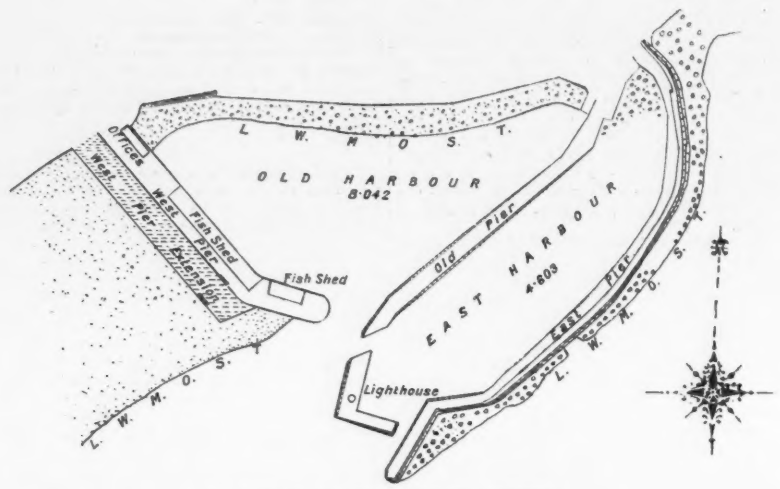


Fig. 1—PLAN OF SCARBOROUGH HARBOUR

At the height of the fishing season, which happens to coincide with that of the holidays, the port presents a most animated scene. The well-sheltered bay is dotted with smacks and trawlers of every rig and description, and the East and Old Harbours, the combined area of which does not exceed fourteen acres, are so closely packed with fishing craft from Scotland, Lowestoft, Grimsby, and other ports, that it is often possible to cross from place to place by walking over the decks. On the quays also the bustle is almost incredible. Every available space is occupied by buyers and sellers, those engaged in curing and packing fish, and barrels of herrings ready for export to Russia and Germany.

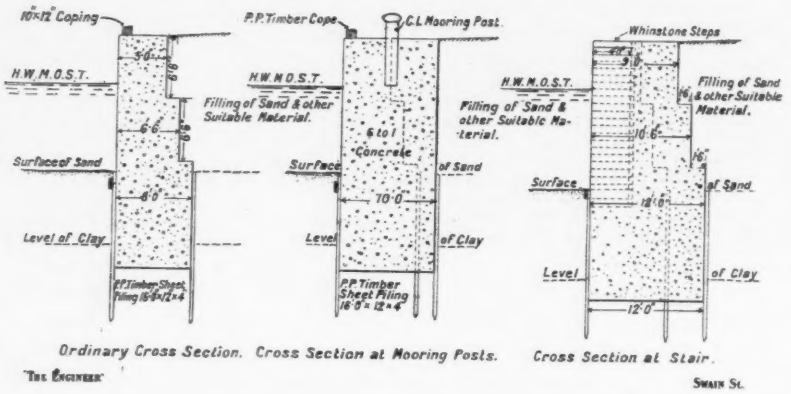
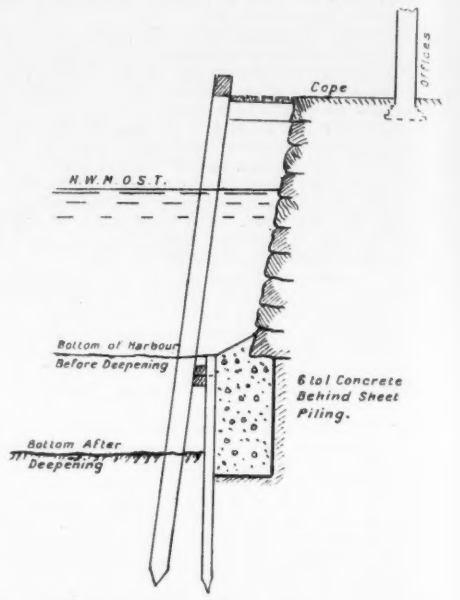


Fig. 2—SECTIONS OF THE NEW WALL OF THE WEST PIER EXTENSION

Where the level of the clay dipped a vertical step was made, and the bottom of the excavation was always kept horizontal. Above the foundation strong wooden temporary shutters, with the inside surface planed, were then erected, and concrete in the proportion of one part of Portland cement to six parts of sand and gravel was put in in layers not less than 2ft. thick, and in lengths of about 20ft. Each length was dovetailed to the next, and in no case was the vertical joint of a length allowed to come nearer than 3ft. to the joint below. The gravel, which was procured from the beach some miles away and was brought to the works in cobles, was of particularly good quality for concrete, as it contained a proper proportion of sharp sand, and the pebbles were of varying size, but nearly all such as would pass through a ring of 1½in. diameter.

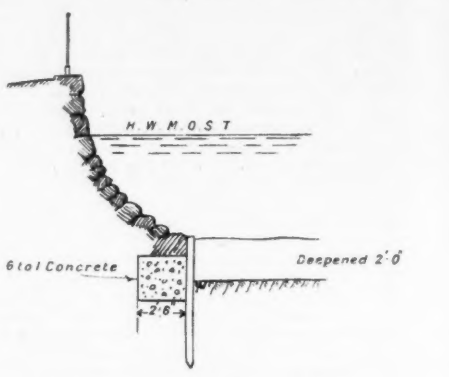
All mixing was done by electrically driven machinery. Cast iron bollards for mooring are built into the wall, and a timber coping runs along its entire length. The space between the old and new walls was filled partly with excavated material from the harbour and partly with sand from outside. When this material had become sufficiently consolidated, whinstone setts were laid at the outer end, and tar macadam, with a bottoming of broken stone, over the rest of the reclaimed area. A much needed addition of some 4300 square yards of quay space was thus made to the West Pier. Sections of the new wall are given in Fig. 2, the first part of which shows the ordinary cross section, the second the cross section at mooring posts, and the third that at a stairway.

The deepening of the old harbour presented some difficulty, as the quay walls are very old, and are constructed of large irregular boulders without any mortar or cement joints. It was necessary to secure these walls by underpinning before dredging operations could commence. This work, therefore, had to be done in short lengths, and great care was required in shoring up the old walls until the concrete had set. At the outer end of the piers, where dredging was carried to 3ft. below low-water mark, the difficulty was accentuated, as no work was possible except for a very short time at the lowest spring tides. Different methods of underpinning were employed at dif-



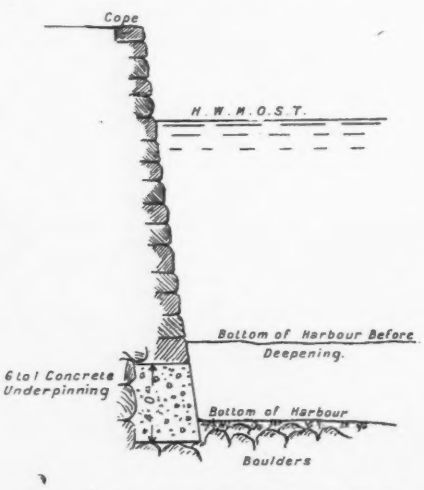
Underpinning Behind Offices.

Fig. 5



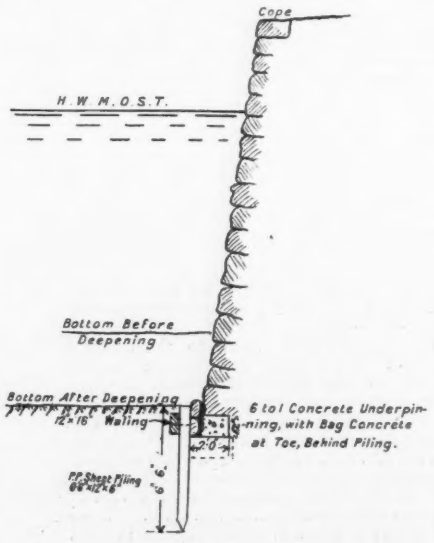
Underpinning for Curved Wall.

Fig. 6



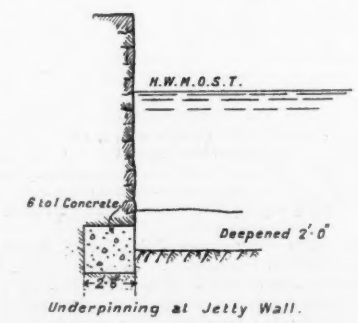
Underpinning where Foundation was Hard.

Fig. 3



Underpinning where Foundation Varied.

Fig. 4

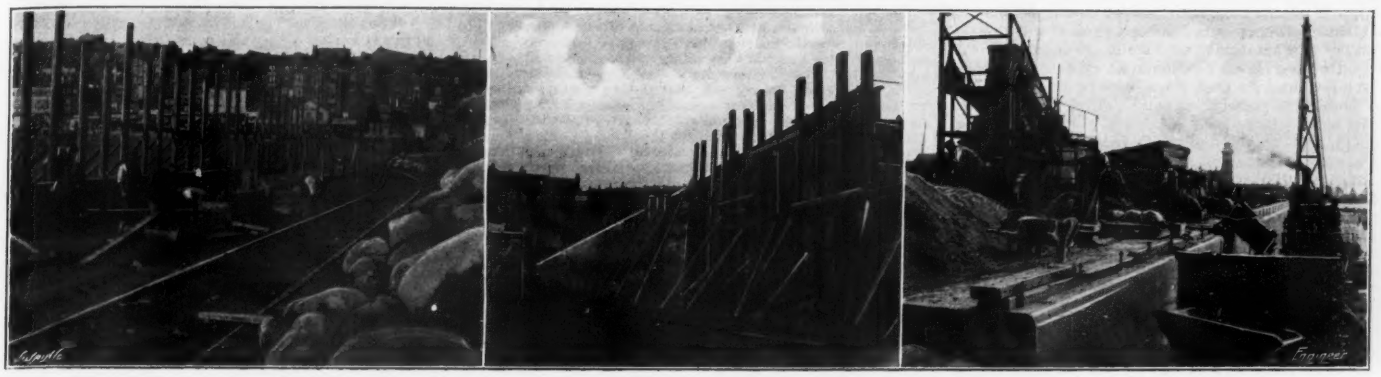


Underpinning at Jetty Wall.

Fig. 7

It can be readily understood that the harbour, although so small itself, is one of the most flourishing centres of the fishing industry in the kingdom; in fact, there are only four English ports where a greater quantity of herrings is landed annually. It was with a view to mitigate this state of congestion that the recent improve-

RECENT IMPROVEMENTS AT SCARBOROUGH HARBOUR



Figs. 8, 9, and 10—VIEWS OF THE WEST PIER EXTENSION WALL DURING CONSTRUCTION

ferent places, and examples of some of these are shown in Figs. 3, 4, 5, 6, and 7. Fig. 3 shows how the work was carried out where the foundation was hard; Fig. 4 where it varied; Fig. 5 behind the offices; Fig. 6 where the wall was curved, and Fig. 7 at the jetty wall.

For the deepening of the harbour a bucket dredger was employed—a view of it is given in Fig. 12, and the "cut" it has made is clearly seen. The depth over the greater

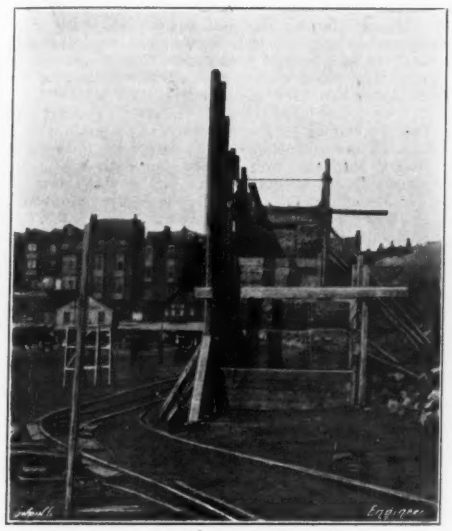


Fig. 11—THE WEST PIER EXTENSION WALL

part of the harbour was carried down to low-water mark of ordinary spring tides, and this necessitated the removal of an average thickness of some 4ft. over the entire area except near the entrance, where the depth was carried some 3ft. lower. The material to be dredged consisted for the most part of boulder clay, and some very large boulders were removed. In some places the boulders were packed so tightly together that blasting had to be resorted to before they could be dislodged. At the upper end of the harbour or Hard, the excavation was done by spade, and the excavated material was removed in tip wagons drawn by a small locomotive, and deposited behind the new West Pier wall. The contractors were Messrs. Firth and Co., of Derby.

Towards the cost—some £12,000—of the improvements described above, a grant of £4000 was obtained from the Treasury. The work was carried out from the designs and under the superintendence of Mr. J. D. Howkins, engineer to the Hartlepool Port and Harbour Commission, to whom we are indebted for the information contained in the foregoing and for the illustrations, and the resident engineer was Mr. A. E. Stevenson.

The other illustrations which we are enabled to reproduce show in Fig. 11 the new West Pier walls, with the crane and wagon roads; in Fig. 8 the wall with men erecting shuttering; in Fig. 9 the same, with the shuttering partly removed, and in Fig. 10 the same again, showing the concrete mixer, the motor shed, the crane,

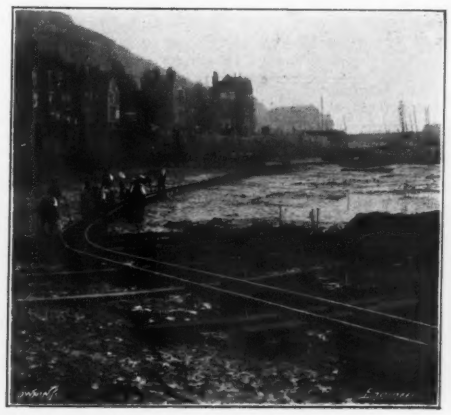


Fig. 13—THE OLD HARBOUR, SHOWING EXCAVATION

and also the wagons, the boilers, and the holding down bolts for the coping. Fig. 13 gives a view of the old harbour, showing the excavation of the Hard slope next the Foreshore road, the Wagon road, &c.

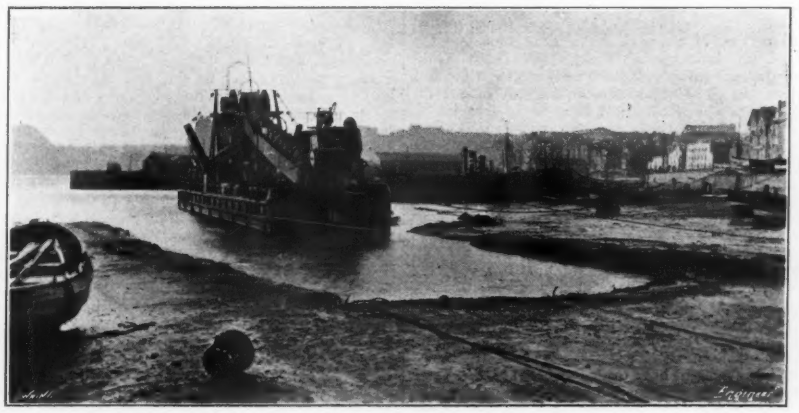


Fig. 12—BUCKET DREDGER

GUNS OF THE UNITED STATES NAVY.

REAR-ADMIRAL N. E. MASON'S annual report to the Bureau of Ordnance of the United States Navy for the current year is of considerable interest, inasmuch as it gives us a very good general idea of the advance of navy ordnance material on the other side of the Atlantic.

Rear-Admiral Mason tells us that the most important developments of the year have had to do with guns and their mounts, with powder and projectiles, with armour, with torpedoes, and with that much vexed question, efficient fire control.

In anticipation of the evolution of a more powerful gun for the all-big-gun battleships, the Bureau, about a year ago, began the construction of an experimental 12in. weapon of 50 calibres. This gun has been completed and tested at Indian Head, and the official results show how well it compares with weapons of corresponding weight and calibre elsewhere. In proof, this gun, weighing 54.7 tons, has developed an initial velocity of 3030 foot-seconds and a muzzle energy of 55,446 foot-tons. The powder charge was about 365 lb. In five rounds, fired at 17,000 yards range, the dispersion was less than 100 yards. The battleships Arkansas and Wyoming will carry guns of this type, and it is believed that these vessels will be the first in the world to mount weapons of such power.

A type of 14in. gun is now complete, and will probably be tested before the end of the year. It is designed to fire a projectile weighing 1400 lb. with a velocity of 2600 foot-seconds, representing a muzzle energy of 65,600 foot-tons. A mounting has likewise been worked out for this gun, so should the weapon prove a success—as there is every reason to expect that it will—then the Bureau will be in a position to proceed with the prompt manufacture in case of a demand. In thus anticipating a probable eventuality, the Bureau is saving time and the long delays commonly incident to designing and testing a new weapon. It can now go ahead with definite accomplishments and have a radical advance in ordnance immediately available.

The guns for the Florida and Utah are so far advanced that they will be ready for emplacement long before the ships are ready for them. As is now known, the batteries for these vessels are ten 12in. guns of 45 calibres long, designed with a new type of powder chamber and with increased strength along the chase. The first of these weapons has given very satisfactory results at the proving grounds, and it is intended to assign to them a service muzzle velocity considerably higher than that of the other 12in. guns now afloat, and thus augment their power. The secondary batteries for these ships are composed of sixteen 5in. guns of a new mark, which are especially adapted for torpedo defence. These anti-torpedo weapons use a cartridge case and have a service muzzle velocity of 3150 foot-seconds. The projectile weighs 50 lb.

Admiral Mason reports that the work of relining and modifying the 12in. 40-calibre Mark III. guns has been pushed forward as rapidly as possible, and these altered weapons have been placed on the battleships Ohio, Missouri, and Virginia, and on the monitors Cheyenne, Ozark, and Tonopah, and will be likewise supplied to the other battleships of the Virginia class, and to the Maine as fast as they are completed and opportunity is afforded for their emplacement. The increase in power gained by relining and hooping these guns to the muzzle is very great, making them, so it is said, nearly equal to the 12in. 45-calibre Mark V. pieces. Admiral Mason says these changes "more than warrant the expenditure incurred," and such would certainly seem to be the case and a happy stroke of economy.

The batteries for the torpedo-boat destroyers just completed and for the large fleet colliers are to be composed entirely of 3in. semi-automatic guns. These weapons are of interest inasmuch as they are to be fitted with a newly designed breech mechanism which, it is said possesses certain desirable features tending to reduce the stress upon the breech block, and to make the guns better adapted for mounting on the open decks of destroyers and colliers.

Turret mountings.—The decision to place guns of higher power in the turrets of the two battleships authorised during the present year necessitated the designing of a new mount. Admiral Mason says:—"Advantage was taken of this to incorporate certain improvements in the design, notably placing the trunnions nearer the front armour plate than heretofore, and thereby reducing the port opening to the minimum considered advisable. These new mounts will also embody a feature whereby it will be possible to easily place the pair of guns in a turret parallel to each other, and to correct variations from parallelism which occur after installation, resulting from deformation of the structure due to firing stresses."

A pneumatic ammunition hoist of novel design was erected, and tested in one of the 8in. turrets of the Massachusetts; the tests were quite successful, and the company which supplied the hoist is now working on the plans of one for a larger calibre turret. Should this design appear practicable the construction of a hoist of the type for erection and trial in a turret of one of the older battleships will be recommended.

During the present year new sight telescopes of improved optical qualities and new and better training

sights have been supplied to the turrets of practically all vessels, except the earlier monitors. The experience of the fleet in setting the turret sights to a rapidly changing range at the last battle practice pointed to the necessity of improving the mechanical arrangements for this operation if practicable. A plan for new and improved sight setting arrangements has been worked out.

Powder.—Preparations are well in hand for the extension of the Naval Powder Factory at Indian Head, and in a few months that plant will be able to turn out about double its present output. During the past fiscal year the factory turned out 801,284 lb. of new powder and 432,797 lb. of re-ground and re-worked powder. The new powder cost 0.432 dols. a pound, and the re-worked powder cost 0.156 dols. The object in adding to the Government plant is to enable the service systematically to bring up to the proper amount its reserve supply of powder. Admiral Mason says:—

> There have been no radical changes during the year, nor are any such changes to be anticipated in the near future. Our present nitrocellulose powder has been brought to a degree of perfection which leaves comparatively little room for improvement. New specifications have been prepared by the Joint Army and Navy Board on smokeless powder, which will reduce within very narrow limits the tolerances permitted in manufacture, thus ensuring greater uniformity of product than has heretofore been attained. A more important change has been the addition to the powder of a very minute quantity of a substance which is found to protect the stability of the powder. It is believed that this change will prolong the safe life of the powder by a number of years beyond the period heretofore estimated. The ballistics and stability of the powder are good, and certain suspicions of variation in ballistics which were formerly directed against the powder have been shown to be unfounded, such variations proving to be due to other causes.

The Special Board on Naval Ordnance recommended that all dry houses be converted to the closed-circuit system and a minimum amount of air be used in drying the powder. This has been carried out, and the fans are run by steam engines—the exhaust serving to heat the house. The point of this recommendation is brought out by the fact that it has been found, after careful study at the Naval Ordnance Laboratory, Cavite, P.I., that the main cause of deterioration of powder at that station has been determined to be due to moisture. With proper precautions, and if dried out completely without the use of high temperatures, there is reason to believe that the great bulk of powder of inferior stability on the station could have its life prolonged for several years, thus making it available for use in target practice. Advantage has been taken of the Cavite laboratory to study the effect of tropical light, and light combined with moisture, on the deterioration of smokeless powder; and to investigate the effect of variations in temperature of storage on powder. The constant surveillance of samples of the various lots of powder carried in the magazines of the ships on the station have made it possible to keep the commanding officers of those vessels informed at all times regarding the condition of the powder on shipboard with a degree of accuracy not otherwise easily practicable.

A simple and efficient method has been developed for testing on shipboard the stability of smokeless powder, and testing outfits are being issued to the service as fast as they can be manufactured. The importance of this cannot be over estimated. Only a few years ago awe-inspiring instructions were issued by the Bureau of Ordnance describing a series of most delicate and exacting tests which were to be made from time to time by the ordnance officer of each ship to determine the condition and stability of the smokeless powder in the magazines. Not infrequently this work was done by even less skilful subordinates and by men not over-trained in the niceties of differentiating chemical conditions. As a result, a good deal of powder that was quite safe was given a black mark without good and sufficient cause, and in one instance about 50,000 dols. worth of this propellant was dumped overboard needlessly. Admiral Mason informs us that experiments are still going on in the effort to evolve a new form of smokeless powder, and with very fair results. Progress has also been made in the way of reducing erosion due to high explosive temperatures, which promises to increase the life of the navy's guns.

Projectiles.—In connection with projectiles, as reported last year, certain improvements in form have yielded material increase in range with correspondingly flatter trajectories, wider danger space, and, finally, greater striking velocities and better penetrations at long ranges. Notwithstanding these achievements, however, Admiral Mason says: "It is again necessary to call attention to the unsatisfactory condition of affairs in connection with the reserve supply of armour-piercing projectiles. At present only three firms hold contracts for large armour-piercers, and satisfactory deliveries are not being made. The Bureau is using every effort to assist the manufacturers in the task, which must be recognised as a very difficult one, of developing a projectile which will meet the very severe demands of our present specifications. The difficulties have been temporarily somewhat increased by a change of form which has been adopted for obtaining increased range, but it is believed that this feature of the situation will not prove serious." It is to be hoped that Admiral Mason's optimism may be justified. The adoption of the more pointed shell—an adaptation of the lines of the Spitzer bullet—involve some decided difficulties, and these have not yet been satisfactorily surmounted.

One very practical step in the direction of improving the accuracy of fire when the gun has suffered from erosion has been taken by broadening the rotation band of the projectiles. Admiral Mason says of this change:—

> It is expected to considerably prolong the life of the gun by ensuring a true flight for the projectiles after the gun is much worn that its accuracy with the older bands would have been much impaired.

> In the service generally there seems to be an increasing appreciation of the fact that modern ordnance consists largely of instruments of precision, some of which are necessarily delicate, and that these are entitled to the same care as other instruments of precision. This disposition in the service toward more intelligent care and more considerate handling of ordnance material has been very gratifying, and, combined with improvements in various parts of the material itself, has resulted in comparatively few casualties during target practice. A few exceptions have occurred where it has seemed that the ordnance material has been abused, apparently through misdirected zeal and a lack of considerate handling, combined perhaps with a lack of thorough familiarity with the proper functioning of the parts which failed.

> This summary of the Bureau's work would be incomplete if it failed to call attention to the great amount of work expended upon the design, manufacture, and test of sights, firing mechanisms, fuses, and other minor but absolutely essential articles of ordnance equipment. Great improvements have been made in all these directions, and the Bureau feels that it may properly express its gratification at the remarkable results which have been obtained in target practice with material which, in many cases, was designed before anyone could have predicted the demands which would be made upon it as a result of the unprecedented development in target practice within the last few years.

In conclusion, Admiral Mason invites attention to the work of the Special Board on Naval Ordnance, which is advisory to the Bureau, and largely directs the line of all experimental investigations.

> As many of the subjects with which the Board has been and continues to be engaged are essentially confidential in their nature, they can only be referred to here in general terms. The following partial list of subjects will give some idea of the importance of its work:—

> An investigation of the behaviour of powder in the gun, looking to the more complete solution of the problems of interior ballistics and to practical improvement in smokeless powder.

> An investigation of the flight of projectiles as affected by the form of the head, looking to a possible increase in range, penetration, and uniformity of flight.

> A study of the erosion of guns, looking to the possibility of reducing this by modifications in the composition and granulation of the powder.

> A study of the rotation of projectiles as affected by the material and dimensions of the rotating band, especially after the guns have become seriously eroded.

> Experiments with high explosives for the bursting charge of shells and the perfecting of a fuse for use with such explosives.

> The angle of impact of projectiles at long ranges and the effect of this angle upon the penetration of armour.

> All of the above questions are of great and pressing importance to the service. The sum of 200,000 dollars for experimental work along these lines has been included in the estimates for the coming year, and it is considered very desirable that this sum shall be allowed in full. Every dollar expended in the solution of problems like those outlined above gives a direct and tangible return in the increased efficiency of every individual feature of the offensive and defensive power of our ships.

THE PEKING-KALGAN RAILWAY.

THE opening of the Peking-Kalgan Railway in October last marks a period in Chinese history that will be watched with interest by all those connected with the Far East. The funds for the construction of this railway were obtained from the profits of the Northern Railway, and the line has been built by the Chinese themselves, and is now worked by them also, though, doubtless, in both cases, with some advice from the engineers of the Northern Railway. The engineer-in-chief, his Excellency Chang Tien Yow, is much to be congratulated on his work, which is one of the most difficult railway undertakings that have been carried through in China, and one that must become more important as the work is advanced, forming as it will the most direct route to the Far East, if linked up with the Trans-Siberian Railway near Lake Baikal.

The railway connects with the main line to Hankow at Fengtai Junction, a place well known as the scene of the Boxer outbreak in 1900, where several Europeans lost their lives, and others escaped with difficulty. For people living in Peking the most convenient station is the Hsichihmen, which is within a short distance of the North-Western Gate, from which it takes its name; from here visitors can start to see the Ming Tombs or the Great Wall. Between Chingho and Shaho on a fine day a good view may be obtained of the Summer Palace, the western hills forming a background that shows the golden roofs of the palace glittering in the sunshine. The first 30 miles of the road are flat and uninteresting, with little life to be seen, except the pack trains of mules, donkeys, and camels, laden with skins, furs, and other produce of Mongolia for the Peking market. Near Shaho a serious wash-out occurred last summer that cost the Government 800,000 taels, or about £32 000, to repair and build extra culverts. As such an extraordinary flood had not been known for over forty years, it is hoped that the improvements will secure safety in the future. Although this country is fairly flat, the difficulties to be met with are great, for at times the roads—which are, in fact, the river beds at certain seasons of the year—become impassable torrents of uncertain and unbanked channels. The water thus spreads over a wide area, many culverts are required, and long retaining walls to direct and hold the river in its course must be erected.

Towards mid-day the train arrives at a small town named Nan Kou, at the foot of the pass that guards the entrance of the main road northwards through the Great Wall. Repair shops and a running shed have been built outside this town, and here the chief difficulties of the engineers commenced, a height of about 1500ft. having to be attained in 13 miles at a place called Ching Lung Chiao, the summit of the pass. At Nankow are stationed the three Mallet locomotives that were supplied by the North British Locomotive Company, of Glasgow, to work the trains up the steep gradients of this part of the road. The usual train consists of about 30 axles, or 180 tons, exclusive of engine and tender, and these engines work up the distance of 13 miles in two hours, a good performance, considering the curves, which have a radius of 600ft. To avoid the chances of a breakaway, the engine pushes the train to the top of the Ching Lung Chiao gradient, where a smaller engine couples on and works the train to the terminus at Kalgan. The road up the pass is chiefly laid on the side of the hill, though there are many places where embankments have had to be built across gullies or round spurs of the mountain. Great care and forethought have evidently been spent on these works, and at places where the rivers have their course at the foot much expense has been incurred, and the foot of the embankment has been faced with blocks of concrete and stone.

Between Nankow and Ching Lung Chiao there are four tunnels, the last being 3580ft. long; this one has been cut 200ft. below the Great Wall. Before entering this last tunnel, and also on leaving it, a magnificent view is obtained of the surrounding country, and also of the old pack road, with its constant stream of toiling camels and other animals. The old and the modern methods of transport side by side furnish thought for many questions, and one wonders whether the old conservatism of China has really passed. On reaching the summit of the pass the line emerges on to a plateau, where there is little of interest, and, with the exception of one short section of 1 in 100, the gradient is easy. The country is brown, dusty, and wind-swept, and the towns and villages built of mud, with substantial mud walls enclosing them. Here, too, the earthwork will require careful watching, as the rivers have no well-defined channels, and after heavy rains are apt to cause much trouble. On reaching Kalgan, the terminus, travellers will be much surprised to find such a busy place. All day long the pack trains are arriving in the station yard, and numberless coolies are employed loading the cargo into the railway wagons. From any one of the surrounding hills an idea can be obtained of the extent of this huge plain and the probable route of the extension towards Urga.

From a technical point of view the engineer has much to be proud of, considering the difficulties that he had to contend with. Fault might be found with the angle of the earthwork in places, but this is being corrected, and, whatever may be said, the work has every appearance of being most substantial throughout; in fact, the buildings are an example of lavish expenditure, many being of dressed stone, though the work is said to compare very favourably with other railways from a financial standpoint. The rains will no doubt require much careful attention for some time, as there seem to be hardly enough culverts through the embankments to carry off the surface water. The permanent way is well maintained, and spikes are used in place of chairs to secure the 85 lb. rails. On the whole, the engineer seems to have spared no expense or labour to demonstrate that the Chinese were capable of constructing their own railways on substantial if not on modern lines. As to details of cost and maintenance, and any other of those items dear to an engineer who has been on railway construction, these will probably never be published, though if they were, it would not be possible to compare them with any other railway in China, for nowhere else have such natural difficulties been met with in construction.

As a purely Chinese managed railway the methods of working are unique and even exciting, as, for instance, in shunting, the train being a mixed one. The freight cars are uncoupled from the train and form a buffer to the passenger coaches for other cars that are shunted with "flying shunts," roars of applause from the spectators greeting each shunt as the cars get nearer and nearer to the main body of the train. The station staff would also appear to be ample, one station with six trains in and out daily having two stationmasters, two telegraph clerks, two booking clerks, one train despatcher, four station coolies, one shunter, four pointsmen and four servants. It seems impossible even with a good man at the head of affairs in China to eradicate "squeeze." Perhaps, however, the staff is in keeping with the machinery equipment of the stations, a few details about which may be of interest. Between the two termini, Fengtai and Kalgan, there are five engine sheds, six turntables, and ten water cranes, the termini being fully equipped in every way. The coal in use is from a mine worked by the railway near Hsiahua, and the output will shortly reach 400 tons a day, which will be ample for the requirements of the 124 miles of line now open. There is also a coal mine on a branch line at a place called Mentoukou, about sixteen miles from Hsichihmen, and the coal from both mines is of fair quality. Steel bridges are not plentiful; there is one, however, on the main line of seven 100ft. spans, and one on the branch to the coal mines of eight 100ft. spans. The rolling stock was mostly built at the Tongshan works of the Northern Railway and consists of 57 passenger coaches and over 300 wagons of various kinds and capacity. There are also 23 locomotives, some British built and others bought from the Northern Railway. The gauge is the standard one of 4ft. 8½in. and the rails are 85 lb. We feel sure that no engineer could travel over the line without congratulating His Excellency on having successfully undertaken a work of such magnitude.

CONTINUOUS ANNEALING FURNACE.

MANY advantages have been found in automatic continuous heating for annealing or hardening small steel and iron parts, the work being fed from a hopper into the revolving hearth so as to come in contact with the hot lining and the heated gases. This movement has been found to be much more effective than when the material remains in a fixed position. Internally-fired rotary furnaces have proved very useful for the continuous process. Oil and gas fuel are used with satisfactory results. For annealing, the air inlet may have to be controlled to prevent oxidation, but where the work is to be hardened, the discharge end can be placed directly over the cooling bath. The Rockwell furnace of this system—built by the Rockwell Furnace Company, of New York—was first made horizontal, with a helical groove of rectangular section formed in the refractory lining, so as to feed the material through the revolving horizontal cylinder. Long pieces and unsymmetrical pieces, however, tended to choke the groove, and the furnace is now made with the revolving cylinder slightly inclined and fitted with a smooth cylindrical lining. The inclination can be varied to regulate the speed of passage, and thus vary the period of heating. The cylinder rests on two pairs of rollers carried on pedestals on the tilting bed plate; this also carries the fixed feed hopper and fixed discharge head, the latter having the oil or gas burners and their triple connections. The shaft carrying the two rollers on one side, is driven by bevel gear, with a chain drive to a belt pulley. The temperature is adjustable. The product is delivered by a spout into a cooling tank, in which runs a bucket conveyor discharging the articles into a truck or wheelbarrow. The furnaces are built in sizes up to a capacity of 2000 lb. of material per hour.

THE CHEMISTRY OF FLAME.—The juvenile lectures this Christmas at the Royal Society of Arts will be delivered by Professor Harold B. Dixon, M.A., F.R.S., on January 5th and 12th, his subject being "The Chemistry of Flame." The subject is one that lends itself to experiments, and the nature of flame, the properties of oxygen, the nature of various combinations of air and gas, will all be very fully illustrated and explained.

RAILWAY MATTERS.

WE hear that the Swedish engineer, Quitsgaard, has drafted an important scheme for the construction of an electric railway under the Baltic Sound.

THE *Mexican Herald* of 3rd December states that a new railway company formed with a capital of 5,000 000 pesos—about £510,000—for the extension of the Interoceanic Railway from Tezuitlan to Nautla, Veracruz, intends to begin work at once on the first section of the new line, from Tezuitlan to Tlapacoyan.

WE hear that experiments have been made on the Prussian State Railways with ball bearings for car axle journals. They are said to have shown a decrease of about 10 per cent. in the resistance at a speed of 25 miles an hour, and a much greater decrease in the power required to start. These bearings, after 250,000 miles run, were still in good condition.

THE Burma Railways Company, states the *Iron and Coal Trades Review*, intends to replace the existing timber trestle bridges and timber girder spans on the Lashio branch, between Mandalay and Lashio, by steel girders resting on brick masonry abutments and piers. The timber work in these bridges is said to be subject to rapid decay in the wet and moist climate of Burma.

IT is announced that the Gas und Wasser Verein, der Verband, der Elektrotechniker, und der Strassen und Kleinbahn Verein have appointed a joint commission to investigate and report upon the question of earth currents and their effects. Two experts, who will go fully into the question of the effects of the tramways on the gas and water mains at Brunswick, Cassel, Nuremberg, Beuthen, Düsseldorf, and Warsaw, have been engaged.

THE traffic manager of the Grand Trunk Pacific Railway recently stated that the progress of the line was at present giving every satisfaction, and that there was no doubt in the minds of the directors that through trains between Montreal and the Pacific Ocean would be running in 1912. Great wharves are being constructed at Victoria, at a cost of £20,000, and the work at Prince Rupert, the Pacific terminus of the line, is well advanced. There will shortly be a line of steamers operating between Prince Rupert and Victoria, acting as a feeder for the railway.

IT is reported from Winnipeg that arrangements have been completed whereby the Alberta and Great Waterways Railway Company will start work in the spring on the remaining 200 miles of the line to Fort Murray, in the far North-West. This will make it possible for settlers and sportsmen to gain direct access to the 4000 miles of navigable rivers and lakes lying in the region round Lake Athabasca. Steamers will run right up to the border of the Arctic regions, and in addition to tapping a territory believed to be rich in agricultural and mining resources, sportsmen will be provided with a veritable paradise, for the district has been by no means overrun hitherto.

IT is the practice of the Cincinnati Traction Company to soak the car motor brushes in sperm oil, which is said to keep them from chipping, and greatly to improve the surface of the commutators. Two sets of brushes are provided for each motor. The lead brush of the No. 1 motor on a car carries the number of the car and the motor numbers, the other brushes are indicated by scratches. One of the two sets of brushes is kept in oil while the other is in use, and a shift is made about every third night. A high-grade Columbia brush is used, from which excellent results are obtained, even though the steep hills in Cincinnati require the motors to work under severe loads.

IN a letter to the Cheshunt District Council the manager of the Great Eastern Railway states that his directors are unable to comply with a request that the branch line from Edmonton to Cheshunt should be reopened for passenger traffic and worked by a motor service. They feel sure that there is no possibility of any large measure of traffic being attracted back to the railway even with a frequent motor service, owing to the constancy of the service of cars on the tramway along the public road. The cost of working a motor service has been very carefully inquired into, and the expense is found to be far greater than the revenue that the company could hope to obtain, leaving out of consideration the considerable initial outlay that would be required before such a service could be instituted.

IT is now very generally recognised, states the *Railway News*, that the electrification of suburban lines is all a question of density of traffic and whether there is the pressing need for improved terminal facilities which would warrant the large capital expenditure involved. A sidelight is shed upon the aspect of the demand for electrification by the decision arrived at, that the cost of electrifying the Chicago suburban lines is prohibitive, and the authorities of the city of Chicago have been informed of this recent decision. The railway view of the case was presented to the City Council at a recent conference with Mr Harahan, who made his position clear by stating that he believed the cost of the improvements to be greater than any company would be warranted in making. President Harahan proposes to report to the stockholders that the electrification of the Chicago suburban lines would mean a reduction in their dividends, probably of 2 per cent.

THE use of reinforced concrete in the United States in connection with railway work is growing. At a recent meeting of the Concrete Institute, Mr. N. L. Humphrey, who is secretary of the American Joint Committee on Concrete and Reinforced Concrete, referred to this point. He reminded the Institute that, in 1893, when the first bridge constructed of concrete was built in the States, it was not deemed possible that so important a structure as a railway bridge could be made of concrete, and the first bridges so built were very massive affairs. Now much of the massive material has been cut out, and bridges of great beauty are being erected all over America, and, in fact, the use of concrete for bridge construction is quite a common thing. Railway engineers were among the first to realise the advantages of such structures. Not only is the first cost less, but they cost less to maintain. Nearly all the towns in the States now seem to vie with each other in the erection of such bridges. Concrete is now used largely for subways in Boston, New York, and other places, and the material is peculiarly suitable for this purpose where the situation of the work is generally damp.

IN his presidential address before the Institution of Electrical Engineers, Dr. Gisbert Kapp said that in Switzerland the Federal Government appointed some years ago a committee of electrical and railway engineers to report generally on the question of electrifying the Swiss railways. The first report dealt with the amount of power required, and urged the Government to secure water-power rights in time. The average power was estimated at 100,000, and that at peak time at 500,000 horse-power. In a second report some standards as to weight and speed of trains, acceleration, horse-power required in starting and running, time interval between trains, and other matters connected with the future electrical service were suggested, while a third report dealt with the question of a standard frequency; but on the question whether the single or three-phase system is to be chosen the committee had not yet pronounced an opinion. From private conversations he had had with Swiss railway men, he inclined to the belief that the decision would be in favour of the single-phase system, especially since by the use of the Deri type of motor it had been found possible greatly to simplify and also lighten the accessory equipment. The first test of this motor for traction was made on the three-phase Engelberg railway, one phase only being used.

NOTES AND MEMORANDA.

CO-PARTNERY shipbuilding yards stand fifth in the amount of work produced during the past year.

PANAMA Canal excavation during November, 1909, totalled 2,458,152 cubic yards, a daily average of 102 423 cubic yards for the 24 working days. During the month 41,368 cubic yards of concrete was laid, and 285,777 cubic yards of fill placed. The work during the month was hindered by the excessive rainfall, which reached 28.50in. for the 30 days. This is very nearly the highest monthly rainfall observed on the isthmus.

A PATENT issued on November 23rd to Messrs. B. G. Lamme, R. S. Feicht, and G. H. Garceau, deals with means for rendering a single-phase induction motor self-starting under full-load torque. The rotor of the machine is arranged to revolve independently of the shaft during the starting period. The arrangement is such that the rotor starts from rest with the machine operating as a split-phase motor. As the speed increases a centrifugal device first opens the auxiliary starting circuit, then short-circuits the added starting resistance in the secondary circuit, and finally clamps the rotor upon the shaft, thereby bringing the shaft with its load up to the full-load speed of the machine.

No use has yet been discovered for tellurium, states an American contemporary. It is classed as a metalloid, and is supplied as a chemical curiosity in the form of a black powder and as a metallic-looking substance with a fine columnar crystal form, in colour somewhat resembling tin. Some of the compounds of tellurium have an offensive, all-pervading, and ineradicable odour. Chemists who have been experimenting with tellurium say, according to the United States Geological Survey, that after three months' exposure to sun, wind, and rain, the clothing worn by them while they were making these experiments, although it had not come into contact with the tellurium compound, was still so unpleasantly scented that it had to be destroyed.

RETURNS for the first three-quarters of the current twelvemonth show a rise in exports as well as imports of motor cars, in comparison with a like period in 1908. Germany imported 45 business automobiles, valued, roughly, at £19 700, whereas in 1908 the number stood at 37 with a value of £17,500. Austro-Hungary's sales rose, while Switzerland's dropped. The latter country sent vehicles weighing, collectively, 21.900 kilos. over the frontier. As to exports, Germany sent 118 vehicles abroad, as against 108 in 1908. The respective values were, however, £67 550 and £70,400; hence, the increase of tonnage was accompanied by a decline in value. The sales in Russia dropped from 91,100 to 72,100 kilos. Great Britain figures but low in the list of buyers.

AN experimental road has been constructed at Truro, by which it is claimed that it has the advantages of being resilient, mud and dust-proof, noiseless, and requiring no removal of the old surface. It consists in spiking down on the roadway sheets of expanded steel similar to those so largely used for the reinforcement of concrete, and laying over it a 2in. depth of ordinary road material treated with coal tar, and rolling well in. The expanded steel is obtained by passing solid sheets of mild steel through a machine, which cuts slits at regular intervals, while the sheets are forcibly expanded, the result being a large sheet of diamond-shaped netting, which, it is claimed, when used in conjunction with properly prepared stone, will give a road surface of considerable endurance.

AN American patent has been granted to Mr. N. G. Warth for an improved telephone repeater. A horseshoe magnet covers the receiving coils. The poles of these latter are bevelled to conform to the bevel of the armature, and a small block is mounted directly upon the mica diaphragm of the transmitter. This makes the moving parts very few. The rear wall of the microphone button is re-entrant, to afford a better disposition of the granules. The air-gap of the magnetic circuit is adjustable through a spacing screw in the transmitter mounting, and the permanent magnet is provided with an adjustable magnetic shunt block for deflecting the polarising field from the air-gap. These adjustments provide for the accomplishment of maximum efficiency of action.

THE investigation of the meteorology of the upper air, by instruments attached to kites and balloons, has been in systematic operation sufficiently long to justify the issue of a report on the subject, which has just been published by the authority of the Meteorological Committee. An introduction to the report by Dr. W. N. Shaw, the Director of the Meteorological Office, gives, in the first place, an historical survey of similar work hitherto pursued in this country. The main body of the report gives a description of the apparatus and methods in use by Mr. Dines at Pyrton Hill, the details relating to the construction and management of kites and balloons being sufficiently precise to afford a most useful guide to any person wishing to take part in so valuable a department of meteorological work.

IT is reported that some successful experiments were recently carried on at Nuremberg in connection with steering a motor boat by means of wireless telegraphy apparatus. At the lighthouse on the lake the antennæ were erected, and on the bridge the transmitting apparatus was placed. On the boat the wire was stretched between two masts 13ft. in height and 13ft. apart. The receiving apparatus was fitted in the forepart of the boat, and in the stern was the switch and electric steering gear. In the course of the trials the boat was made to describe curves to the right or left, and to turn sharply in either direction. The object of the tests was to prove that it was possible to transmit signals to an intermediate point, and thence, as directed by a shore station, to control the steering gear on board a vessel.

THE authorities at the Devonport Dockyard, states the *Electrical Review*, express some fear that the main switches which are placed in each building for controlling the lights, may inadvertently be left in the "on" position at the close of the day, though the various lights may have been switched "off." To ensure, therefore, that at the close of each working day the electric current shall be shut off in all buildings not in use, electrical tell-tales are being fitted to all buildings having separate controlling switches. These tell-tales consist of two electric lamps enclosed in red shades placed against the outside of the buildings over the main entrance. They are so connected up that should the switch be left "on" contrary to the regulations, the lamps will continue to burn, and thus warn the police on duty. When the switch is turned to "off" the tell-tale lamps go out.

THE following notes concerning the storage in California of crude oil in concrete reservoirs were recently given in *Concrete*. A 1,000,000-barrel reservoir lined with concrete has lately been completed at Port Richmond, Cal., and one of 800.000-barrel capacity is under construction near Bakersfield. The practice is to excavate the earth, which in most fields is a sandy loam, porous, and very dry, to about one-third the depth of the proposed reservoir. With the material removed, a levee is built round the excavation, having side slopes of 1 : 1½ on both faces. The bottom and sides are then covered with about 3in. concrete, often reinforced with expanded metal or some equivalent. Small cracks that occur at the junction of the sides and bottom and along the line between the cut and the embankment soon become filled with sediment, and are believed to permit the leakage of very little oil. A number of such structures in Southern California have recently been examined, and no signs of depreciation in the quality of the concrete were found.

MISCELLANEA.

THE Agent-General for Victoria, Australia, has received through his Government a cablegram from the Council of the University of Melbourne advising him that Professor Henry Payne, Professor of Engineering at the South African College, Capetown, has been appointed to the Chair of Engineering at that University.

IT has been decided by the proprietors of the Ascot cinnabar claims at Mackaytown, in New Zealand, to proceed with the erection of plant and furnaces, and it is probable that shortly they will be producing up to 10 cwt. daily of metallic mercury. There is reported to be enough ore at present available to keep up this output for some months, and the deposits are said to become richer as the workings are extended.

THE South Lincolnshire Water Company, which was incorporated by Parliament in 1906, has deposited a Bill for introduction into Parliament next session, under which it is proposed to further extend their limits of supply so as to include the parish and urban district of Holbeach. The Bill also proposes to repeal the powers obtained by them for the acquisition of the undertaking of the Bourne Waterworks Company, Limited, and to annul the agreement with that company.

WE hear that work is rapidly proceeding as a preliminary to the reconstruction of the Quebec Bridge over the river St. Lawrence. The pier on the northern side has been demolished to make way for stronger foundations, and the remainder of the piers are either being broken down or overhauled for use under the new plans. Everything is to be finished by November next according to the contracts, and throughout the winter 500 men will be constantly at work making everything ready for the activities of 3000 bridge-builders in the spring.

ALL over South Africa are salt-pans, many of these having deposits of great value. Few of them are being worked as business undertakings, and such as are are using the most elementary methods for producing their salt in a marketable form. But the industry in Orange River Colony has made an advance by the importation of machinery capable of producing over 80 tons per week. In the northern parts of Cape Colony during the past year many salt-pans have been acquired on lease from farmers, and no doubt the example of the Orange River Colony salt mines will be followed and machinery purchased properly to develop the industry.

ACCORDING to the *Electrical World* the number of electrical plants erected for farms is increasing with marked rapidity, and in their opinion it seems probable that the time is coming when well-to-do farmers everywhere, no matter how remote from a city or village containing a central station, will consider electricity as a necessity. At first the current for these country equipments will be generated by plants on the premises; but as the movement becomes more general, central-station companies favourably situated will no doubt find it to their interest to extend their lines along the rural highways to a far greater degree than is done at present.

AN appendix to the report of the International Conference on Electrical Units and Standards of 1908 has just been issued. It will be remembered that the specifications of the ohm, ampère, and normal cell in the original report were expressed in general terms so as to admit of modifications in details at the various national standardising laboratories. The appendix now issued contains details of the methods adopted at the National Bureau of Standards of America, at the Central Electrical Laboratory of Paris, at the Reichsanstalt at Berlin, and at the National Physical Laboratory at Teddington. References to the literature of the subject are also given, so that this appendix will prove of great use in electrical laboratories.

ACCORDING to the *Electrical Engineer*, Mr. Nikola Tesla has announced that as the result of experiments conducted at Shoreham, Long Island, he has perfected a new system of wireless telegraphy and telephony in which the principles of transmission are the direct opposite of Hertzian wave transmission. In the latter, he says, the transmission is effected by rays akin to light, which pass through the air and cannot be transmitted through the ground, while in the former the Hertzian waves are practically suppressed, and the entire energy of the current is transmitted through the ground exactly as though a big wire. Mr. Tesla adds that in his experiments in Colorado it was shown that a very powerful current developed by the transmitter traversed the entire globe and returned to its origin in an interval of 84 one-thousandths of a second, this journey of 24.000 miles being effected almost without any apparent loss of energy.

AT the Royal Institution last Tuesday afternoon Mr. William Duddell commenced a course of Christmas lectures on modern electricity. Tracing the early work of electrical discovery done by Volta in the later years of the eighteenth century, the lecturer described the structure of Volta's electric "pile," and produced one of the original "piles" made by Volta. This, he said, came into the possession of the Royal Institution as late as 1902. It was presented by Volta to Faraday when he was at the Royal Institution, but so little was thought of it that Faraday handed it to one of his assistants, who left it at his death to Mr. Leigh Smith, through whom it came back to the Royal Institution. Another historic instrument shown by the lecturer was a magnet from the Great Exhibition of 1851. That magnet, he said, was still one of the most powerful in the world. It supported a "keeper" of 4 cwt., and it was only with great difficulty that the keeper could be pulled away.

THE first tests in the United States of firing at balloons were carried out at the Sandy Hook proving grounds on November 27th, when a small three-man captive balloon was anchored at a height of 300ft. and fired at from a distance of 2000 yards. Fifteen shots were fired from a special one-pounder having a range of movement from horizontal to vertical, without hitting the balloon. A larger field gun that could be elevated to about 40 degrees was also tried with smoke-producing shells, several of which passed over and several below the balloon. A third kind of shot was a shrapnel which exploded at a certain set distance, and discharged backward a score or more of balls in a widely expanding cone. The balloon was brought to earth by one of these shot. Before the completion of the tests, which lasted several days, ninety shots were fired with but three hits. Two of these were without effect. As a result of the tests, army officers believe it will be almost as difficult to hit and destroy a dirigible balloon as an aeroplane.

THE Regulations adopted in Germany to prevent the rivers from being polluted provide that in the case of factories the water to be emptied into the river must be in an absolutely clean condition, unpolluted by any residues from the manufacturing process. This is accomplished by sending it through one or more settling ponds, and, if necessary, the waste must be passed through filters. The streams are regularly patrolled by inspectors, and any justified claim against the quality of the waters, due to pollution from the factories, is at once investigated and must be remedied immediately, regardless of the cost. The law is strictly enforced, and in the event of any violation, whether unintentional or not, the manufacturer is required to pay all costs in connection with removing the pollution from the streams. A manufacturer having works adjacent to one of the small streams in Saxony who polluted the water was compelled to bear all the expenses of cleaning the stream, and the cost of this work absorbed the earnings of the factory for several years.

THE VULCAN CEMENT WORKS, NEAR MONTREAL

(For description see page 680)

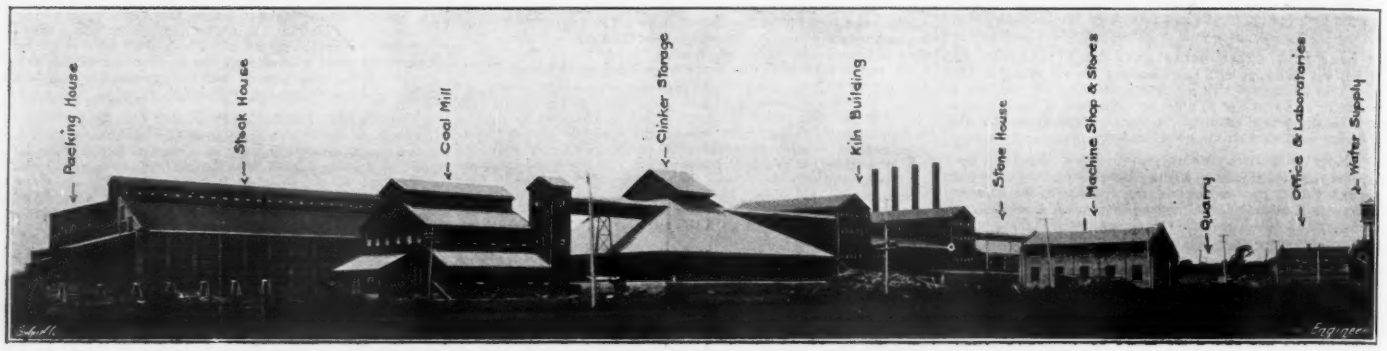


Fig. 14—GENERAL VIEW OF THE PLANT, LOOKING NORTH

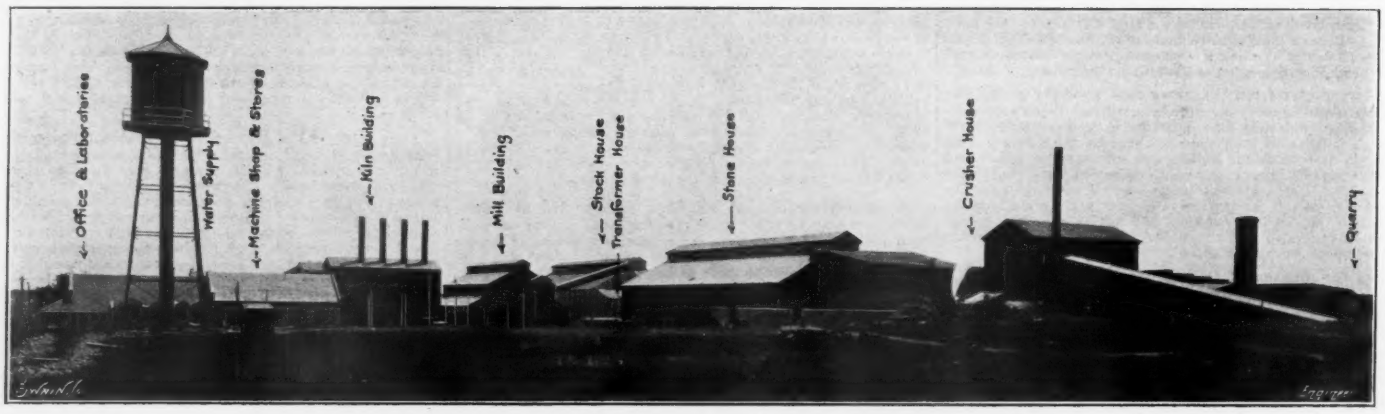


Fig. 15—GENERAL VIEW OF THE PLANT, LOOKING SOUTH

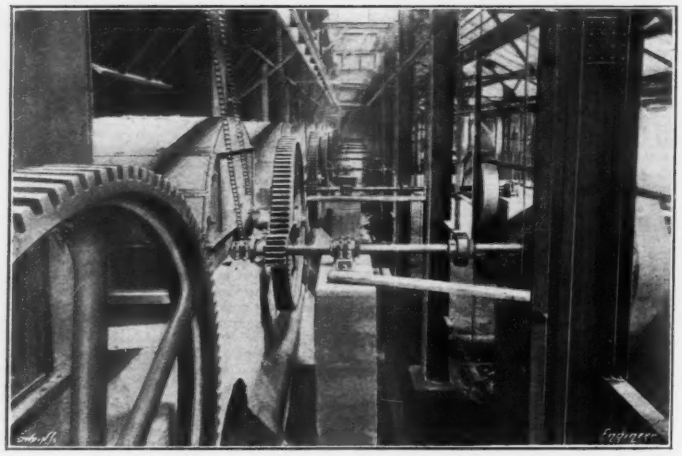


Fig. 16—THE KOMINOR MACHINES

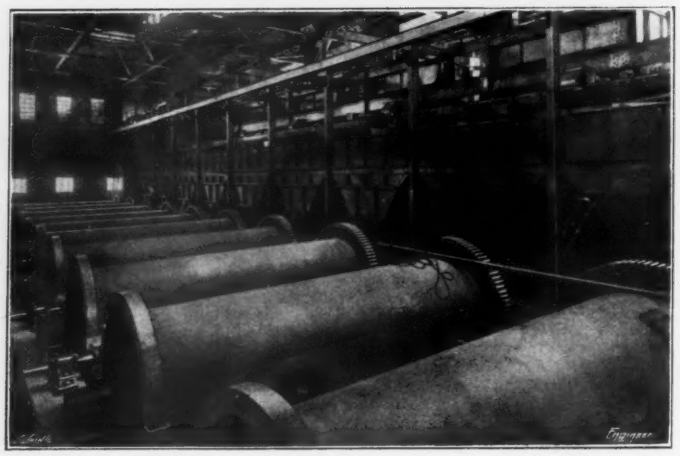


Fig. 17—THE TUBE MILLS

Fig. 18—THE FOUR ROTARY KILNS

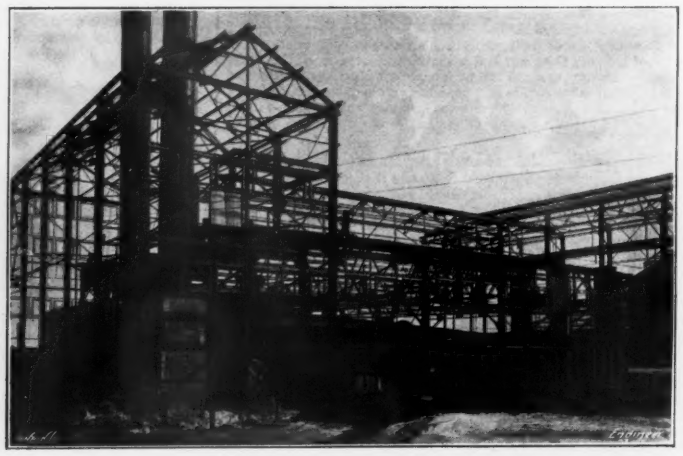


Fig. 19—THE KILN HOUSE UNDER CONSTRUCTION

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Letters relating to Advertisements and the Publishing Department of the Paper are to be addressed to the Publisher, Mr. Sydney White; all other Letters to be addressed to the Editor of THE ENGINEER.

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CONTENTS.

THE ENGINEER, 31st December, 1909.

	PAGE
OUR MINERAL STATISTICS	679
BRITISH AND FRENCH RAILWAY SPEEDS IN 1909	680
NEW CEMENT MILL NEAR MONTREAL. (Illustrated.)	680
THE ROYAL COMMISSION ON CANALS AND WATERWAYS. No. XVII. (Ill.)	683
THE THEORY OF SUPERHEATING	684
DOCKYARD NOTES	685
RECENT IMPROVEMENTS AT SCARBOROUGH HARBOUR. (Illustrated.)	686
GUNS OF THE UNITED STATES NAVY	687
THE PEKING-KALGAN RAILWAY	688
CONTINUOUS ANNEALING FURNACE	688
RAILWAY MATTERS	689
NOTES AND MEMORANDA	689
MISCELLANEA	689
LEADING ARTICLES—The Report of the Canal Commission	691
Briquettes as a Locomotive Fuel—Profits on Steel Production	692
GERMAN COMPETITION IN STEEL	693
LITERATURE	693
THE DETECTION OF FIRE-DAMP. (Illustrated.)	694
A LEAD TRAP PRESS. (Illustrated.)	695
HIGH-SPEED PNEUMATIC HAMMER. (Illustrated.)	696
NAVAL WORK ON THE CLYDE	696
SUBMARINE SIGNALLING	696
SIDE LIGHTS ON WORKMEN'S COMPENSATION	696
COMPOUND STRESS EXPERIMENTS. (Illustrated.)	697
LETTERS TO THE EDITOR	700
CALENDARS, DIARIES, &c., FOR 1910	700
CATALOGUES	700
LETTERS FROM THE PROVINCES—The Iron, Coal, and General Trades of Birmingham, Wolverhampton, and other Districts—Notes from Lancashire—Sheffield District	701
North of England—Notes from Scotland—Wales and adjoining Counties	702
NOTES FROM GERMANY, FRANCE, BELGIUM, &c.	703
AMERICAN NOTES	703
BRITISH PATENT SPECIFICATIONS. (Illustrated.)	703

TO CORRESPONDENTS.

☞ *In order to avoid trouble and confusion we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must in all cases be accompanied by a large envelope legibly directed by the writer to himself, and stamped, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

☞ *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

☞ *We cannot undertake to return drawings or manuscripts; we must, therefore, request correspondents to keep copies.*

REPLIES.

C. F. (Cardiff).—(1) There are a great many devices for plugging boiler tubes, and it would be as well to see what has already been done by a search at the Patent-office before taking any further steps. (2) Address the Engineering Department. (3) Approach people who supply boiler fittings of various kinds. You will find their names in our advertising columns.

A. W.—We would recommend you to consult:—(1) "Electricity in Factories and Workshops," by A. P. Haslam; Crosby Lockwood and Son. (2) "Reinforced Concrete in Europe," by A. L. Colby; London, Williams and Norgate. "Concrete Steel Buildings," by Twelvetrees; Whittaker and Co. (3) "Lathe Design," by Nicolson and Smith; Longmans. "Machine Tool Design," by Parr; Longmans.

H. R. R. W.—It is quite impossible with the data at hand to arrive definitely at the consumption of gas in the period you mention; first, because you, presumably, do not know when the meter went wrong, and secondly, because the supply pressure varies throughout the twenty-four hours, and the leakage would nearly certainly vary with it. You will have to abide by the by-laws of the gas companies, which are fully recognised in such a case as you propound.

MEETINGS NEXT WEEK.

ROYAL INSTITUTION OF GREAT BRITAIN.—At 3 p.m., at Albemarle-street, Piccadilly, W. A Christmas Course of Experimentally Illustrated Lectures, adapted to a Juvenile Auditory, on "Modern Electricity," by Mr. William Duddell, F.R.S., M. Inst. E.E., M.R.I. Tuesday, January 4th, "The Generation of Electricity." Thursday, January 6th, "Electric Oscillations." Saturday, January 8th, "Electric Lighting."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 7th, at 8 p.m., in the Institution House, Storey's Gate, St. James's Park, Westminster, S.W. Extra general meeting. Papers: "The Application of the Pitot Tube to the Testing of Impulse Water Wheels," by Mr. W. Rankine Eckart. "An Account of a Visit to the Power Plant of the Ontario Power Company at Niagara Falls, with Extracts from Papers by Officials of the Company," by Mr. C. W. Jordan.

THE ENGINEER.

DECEMBER 31, 1909.

The Report of the Canal Commission.

THE final report of the Royal Commission on Canals and Waterways dealing with England and Wales and Scotland, which was issued on Tuesday is a remarkable document, notably on account of the unprecedented findings of the majority, but also as being inconclusive in many important respects. We say the document is a remarkable one, but it is also an anomaly, for although the Majority Report is signed by sixteen members out of the nineteen now constituting the Commission, this mere statement of figures by no means represents the true feeling of the Commission as regards the contents of the volume. No less than four of the signatories of the Majority Report also sign a memorandum of reservations which distinctly and conclusively states their entire disagreement with the contents of the principal document, with the exception of the historical and descriptive portions and a few minor recommendations, as to which there is practical agreement on the part of all the members of the Commission. Another signatory to the Majority Report, Mr. Russel Rea, also contributes a reservation as to a portion of the recommendations, which, if correct, destroys the traffic calculations and the financial assumptions founded thereon contained in the Report. The three members who have not attached their names to the Majority Report have each presented individual reports, which dissent practically *in toto* from the views contained in the former document. These individual reports are by Mr. Remnant, Mr. Davison, and Mr. Inglis. Although these three reports arrive at the same or similar conclusions, the writers approach the subject from somewhat different standpoints. Mr. Remnant, in a short but carefully reasoned document, condemns the proposals of the majority on economic considerations. Mr. Davison in his report criticises the transport and financial features of the Majority proposals, and lays stress on the fallacy of attempting to construct a policy of waterways development for our own land based essentially and solely on continental data and experience. His criticisms and conclusions reach to much the same results as the reservations of the four members who have signed the Majority Report. He amplifies and supports their views by figures and facts, and as an answer to the conclusions of the majority, Mr. Davison's report contains in brief form the substance of all the most important arguments which can be brought against the policy of State acquisition and development of waterways. Mr. Davison also makes certain recommendations concerning canals showing vitality, and adds some important suggestions respecting railways. The report which Mr. Inglis contributes to the volume presents, as might have been expected, a view of the questions at issue from the railway standpoint. The report, which extends to thirty-one pages, is a brilliant defence of the railway position, and certainly affords more interesting reading than is usually found within the covers of Parliamentary Blue-books. Mr. Inglis defends the railways in no uncertain language against the charges that have so often been levelled against them, and in some passages does not hesitate to depart from the precedent of colourless and restrained language ordinarily adopted in reports of Royal Commissions. Backed, as Mr. Inglis's statements are, by the weight of his position and expert knowledge, his report must be regarded as representative of the views of railway authorities in general on the question of canal *versus* rail transport.

We have referred to the memorandum signed by the four dissentients, and characterised the Majority Report as anomalous in that these gentlemen—Lord Farrer, Sir John Wilson, Mr. Waldron, and Mr. Killick — while signing the Report, dissent from it in all important respects. It is difficult to understand the reason for this curious action, unless it is that the dissentients felt bound to attach their imprimatur to the excellent and valuable historical and descriptive sections of the Report, which fill a large portion of the volume. With these sections few, even of those most opposed to the policy recommended in the Report, will, we think, find occasion to quarrel, except perhaps in minor details, although Mr. Inglis does regard the historical sketch as seeking to "raise a certain degree of prejudice" against the railway companies in regard to their relations towards the canals. The only other likely explanation of the anomaly in the position of the dissentients seems to us to lie in the fact that the Report is, as we have said, inconclusive. While recommending a policy of State acquisition and extension on a large scale, the majority shelter themselves by recommending that the "Waterway Board" which they propose for immediate constitution "should review the whole situation on the lines of practical business . . . with special regard to finance and benefit to trade and public interests, to the extent of local assistance, to prospects of traffic, and to competition with railways. *If satisfied* that the improvement of the four main routes, or of one or more of them at a time, would be desirable, on these lines, the Waterway Board should propose a scheme or schemes for submission . . . to Parliament." The italics are ours, and it may be that the dissentients, and possibly also some other of the signatories, believe they are not committing themselves to any very definite views or proposals, and are shifting the responsibility for anything which may be done in the future as the outcome of the Report on to other shoulders. This shifting of responsibility is, we venture to think, indefensible, in view of the fact that the Commission has now been sitting for nearly four years, and has carried out an exhaustive inquiry into every aspect of the subject. It may be mentioned that the reports, evidence, and appendices which contain the results of the labours of the Commissioners fill no less than eleven folio volumes, including those which are yet to be issued. Surely, after an inquiry of such a nature, it must be possible to come to some definite and conclusive results, and the implication contained in the Report that the execution of the scheme it elaborates is to be postponed for future consideration would appear to indicate that the signatories have serious doubts as to the soundness of their recommendations. It cannot be doubted that such shirking of responsibility by sixteen out of nineteen members appointed by the King to return answers to certain questions submitted to them will go far to weaken public confidence in the value of such inquiries.

It may possibly be urged by his opponents that Mr. Inglis, in his defence of the railway companies, is biased in his opinions; but even if this view is accepted, it is noteworthy that the Majority Report completely exonerates the railways from the charge of "strangling" the waterways. As to the other members of the Commission who are at variance with the majority no charge of bias can, we think, be maintained. Mr. Davison is an engineering expert completely dissociated from railway interests. Mr. Waldron and Mr. Killick are directors of two important non-railway canal companies, and none of the other dissentients has, we believe, any important interest in railways, with the exception of Lord Farrer, who is a director of the Midland Railway Company. From what we have said it will be clear that the Majority Report is supported

by twelve members of the Commission, including Mr. Russell Rea. On the other hand, the remaining seven members are opposed to the recommendations of the majority in all important respects.

What are the recommendations of the majority? In brief, the Report recommends the appointment of a central "Waterway Board" for Great Britain. To this Board would be transferred the waterways which form the four main routes connecting the Thames, the Severn, the Mersey, and the Humber with Birmingham and the Midlands, together with their important feeding branches. These waterways are referred to in the Report, for the sake of brevity, as "The Cross." It is recommended that the canal portions of these waterways be improved and enlarged so as to accommodate barges having a carrying capacity of 100 tons throughout the main lines, and that the river sections be enlarged to admit vessels of a still larger capacity. These improvements are estimated to cost over seventeen and a-half million sterling, exclusive of the cost of acquisition of the existing navigations. The loans raised to meet this expenditure are to be guaranteed by the State, and the expenditure on acquisition is to be met by a free grant from the State. If, for financial or other reasons, the larger works of improvement are postponed the immediate transfer to the Board of the waterways referred to is recommended, accompanied by minor improvements and some reduction of tolls. We have already mentioned the proposed reference to the Waterway Board of the further consideration of the improvement of "The Cross," and an alternative scheme is also suggested which would have the effect of placing the Waterway Board under the control of the Development Commissioners, appointed under the Act of 1909, as regards the consideration of schemes of improvement prepared by the Board, leaving the actual execution of improvements and control of the waterways in the hands of the latter body. The Waterway Board would also have the duty of proposing the acquisition of other waterways than those included in "The Cross," especially "any British waterways of importance now in the hands of railway companies, which should be included in one or more of the earlier schemes."

The Report contains no estimate of the cost of acquiring the waterways, and it is open to serious question whether the estimates of the cost of improvements which are given are sufficient. It is admitted that the estimate of over 17½ millions does not include such items as interest during construction and other financial charges, engineering, legal, and parliamentary expenses, lighting, provision of inland harbours or wharves and their equipment, and the provision of electric or other traction. Mr. Davison in his report submits an estimate of £22,000,000 as the cost of the improvement of "The Cross," and this estimate excludes the cost of acquisition, financial charges, and installation of tractive power. Again, we have grave doubts as to whether the improved canals will be physically capable of passing anything like the increased traffic anticipated in the Report, which admits that additional expenditure would probably be necessary on the duplication of locks and in other directions in case a traffic approaching the estimate were obtained. Even so, no provision appears in the estimates for such extra works.

It seems to us that forty millions is a conservative estimate of the actual cost of this huge scheme when the whole of the expenditure suggested, including the purchase of the existing undertakings, is allowed for. This is but one item of the scheme the country is recommended to adopt—the first instalment of a general system of State subsidised and State controlled transit in competition with the railways of the country. What the cost would be when the northern and other canals were swept into the net of the State it is beyond us to say, but if the other principal waterways are ever dealt with on a scale similar to the proposals for "The Cross" an expenditure of one hundred millions may be reached without difficulty. We shall have something to say in a later issue on the economic and other aspects of this dubious scheme. It should be mentioned that the recommendations respecting Scotland are unanimous. On another page we publish the first portion of a summary of the Majority Report.

Briquettes as a Locomotive Fuel.

IN our last impression we called attention to the formation at Chicago of an International Railway Fuel Association. We wrote of what had been said at the first annual convention about locomotive coal, and we added that much remained to be said regarding other forms of fuel. These are principally lignite, or "brown coal," and briquettes. We need not take the first into consideration, because lignite has no interest for British engineers. Some of the information supplied concerning briquettes is worth setting before our readers, because it would appear that they manage to burn highly bituminous coal in that shape without producing any smoke worth naming, and to utilise small coal which would otherwise be wasted.

A paper was read by Mr. C. T. Malcolmson, of the Roberts and Schaefer Company, Chicago, on "Briquetted Coal and its Value as Railway Fuel." This paper is at first historical. It then gives a brief account of the industry as now carried on in the United States, which is growing in importance. The difficulties met with lie principally in the binding material, which is in all cases expensive. It has been found that pitch is the best, but ordinary European pitch is useless, as it becomes soft at 165 deg. Fah., and melts at 212 deg. Fah. Briquetting pitch should be hard enough to be transmitted in open cars in the hottest American weather and remain hard. To gain this end all the lighter oils and about 5 per cent. of the anthracine should be extracted. Pitch with a melting point of anything over 200 deg. Fah. will answer. Various forms of press are used in producing the briquettes. It is with the results obtained, however, and not with the process of manufacture, that we have to do. The discussion turned mainly on Southern coal of what is known as the Illinois type. The average fixed carbon is 50 per cent., volatile combustible about 33, ash varies from 9 to 19 per cent. This coal is used as mine run on the engines. That is to say, it is not screened and contains a large quantity of slack. The experiments made with this fuel in the form of briquettes showed a substantial advantage all round. Slack that was really unfit for use in the fire-box of a locomotive became mechanically fit. It admitted of being properly fired, and was not carried into the smoke-box or dropped through the grate. Very striking photographs were exhibited of locomotives working suburban trains, some burning raw coal, others briquettes. The latter show no smoke; the others do. Careful investigation resulted in demonstrating that a saving can be effected of from 20 to as much as 35 per cent. in the consumption of fuel, while the boilers steam much better. It would occupy more space than we can spare to mention the various reasons given to explain the high efficiency of the briquettes. In the main, however, it must be sought in the mechanical adaptation of the fuel to combustion in a locomotive fire-box, and incidentally to the diminution of waste due to the brittleness of the coal. The most noteworthy test, particulars of which were brought before the meeting, was carried out with a standard consolidation freight engine designed to burn bituminous coal in a fire-box of the semi-wide type fitted with shaking grates. The results do not confirm Mr. Malcomson's statements. But the conditions were not the same. Four return trips were made between Scranton and Elmira with large briquette fuel, and to obtain comparable data four similar trips were made with raw coal. Analysis gave for the briquettes 13,690 and for the coal 14,282 B.Th.U.'s per pound—very high values. The results were that the briquettes burned per 1000 ton-miles weighed 106.4 lb. and the coal 99.89 lb., but the average speed with the briquettes was 18.05 and with the coal 17.68 miles per hour. With the briquettes no firing tools were used, and very little shaking was required. The exhaust nozzle had to be increased a quarter of an inch in diameter for the briquettes, with a corresponding reduction in the back pressure. With small briquettes a better result was obtained.

Mr. Malcolmson's paper, and the long discussion which followed it, can leave no doubt on the mind that, given the necessary conditions and a proper method of manufacture, briquettes form an excellent locomotive fuel, and that briquetted fine coal can be burned without smoke, a result impossible without briquetting. On the other hand, it appears to be difficult to get a briquette fuel which is not excessively dirty as regards the trains. This is notorious on European railways; and one speaker during the discussion said that for this reason he had to confine the use of briquettes to freight trains only The conditions, as we have previously pointed out, prevailing in the United States are very different from those ruling here, mainly, no doubt, owing to the characteristics of American coal, which seems to have a marvellous capacity for clinkering the grates. In all cases too we find that at the other side of the Atlantic the rate of combustion per square foot of grate per hour is much higher than it is in this country. It is hard to reconcile this fact with the statements made about the economical excellence of the American locomotive. We are quite unable to explain the discrepancy. The main interest for English readers lies in the fact that briquettes may be found a more economical fuel than coal. Small slack of all kinds is much cheaper than even roughly screened coal of the same kind; and it ought to be as possible to utilise it in this country as in any other. In South Wales a good deal is being done in manufacturing briquettes, and less, but still something, in other colliery districts. So long, however, as coal remains cheap it will be used as coal. But will it remain cheap? All the indications are that it will not. Some of our Southern railways are now paying over £1 per ton for coal, and that not on the foot-plate. Any further rise cannot fail to direct attention to methods of utilising fuel, much of which is now practically unmarketable. These methods may be for the moment unpopular. We fancy that their unpopularity would disappear if anything like a substantial economy could be secured. No one is likely to pay for briquettes if good round coal can be had at reasonable rates. On the other hand, if briquettes are as efficient as the good round coal and lower in price, then the situation is altered. Continental experience has long been in favour of briquettes. American experience seems to be the same.

Profits on Steel Production.

THE important influence which the possession of collieries and coke-making plant brings to bear upon the cost of production of and profits on the manufacture of pig iron and steel has been strikingly illustrated in the case of fourteen of the large works which form about one half of the total constituents of the German Steel Syndicate. All the constituents of the syndicate do not own coal or iron ore mines, but the comparatively few who have neither are gradually endeavouring to acquire their own supplies of coal even if they are unable to secure suitable iron ore mines. The movement in this direction has been proceeding for several years past, and is likely to continue in the future, seeing that the control of coal plays a far greater part in the economical production of iron and steel than that of iron ore in connection with these large undertakings. Apart from this circumstance the supplies of native ore in Germany are insufficient to meet the domestic requirements, so that recourse has to be had to large imports from Sweden and other countries. In particular the rich deposits of iron ore in French Lorraine, to which the attention of British pig iron makers has been directed on several occasions in the past two years, are being drawn upon to a considerable extent by the Teutonic iron and steel producers, and over 2,000,000 tons have been requisitioned from this source in the present year, or twice the quantity obtaining in 1908. This large expansion in the exports is inducing the French iron ore owners to consider the question of increasing the price of the ore which is sent over the frontier mainly from the Briey basin in the Meurthe and Moselle. But if the iron and steel works in the eastern industrial district of France have an abundance of high percentage ore at their disposal, in addition to being able to export a large quantity, they have no supplies of coal near at hand that are available, as the coal deposits discovered in that region a few years ago have been located at comparatively great depths, and it is now considered questionable whether they can be worked on a commercial basis, whilst at the same time the coal is declared to be of an average quality. In the circumstances these French iron and steel producers are compelled to procure several millions of tons of coal and coke from Germany, Belgium, and the Nord and the Pas de Calais every year, and the iron ore exported is therefore largely exchanged for fuel from over the frontiers.

The lack of local supplies of coal and coke, and the cost of carrying them from a distance, are responsible for the fact that the sale prices of iron and steel in the Meurthe and Moselle are usually higher than in the Nord, although less than in the Paris market, where the quotations are generally higher than in any other part of the country. But across the frontier in Luxemburg and Germany, where the sale prices are either controlled by syndicates or regulated by competition, the non-possession of coal mines manifests itself in a different way in the sense that the cost of production is greater, and the degree of remunerativeness is less, than in the case of those works which own collieries. If the question of iron ore is left out of consideration, and attention is devoted solely to the

production of pig iron or steel, it is found that four out of the fourteen works previously mentioned have no coal resources of their own at present, and as two of the four do not give any figures relating to their output of steel, they may be dismissed with the statement that both have paid dividends for the year ended with June 30th, 1909. In dealing with the remainder it is necessary to bear in mind that the price of pig iron declined by 15s. per ton during the twelve months in question, and with three exceptions the gross profits per ton of steel ingots produced experienced a reduction as compared with 1907-08. The lowest profits on this basis were 6s. per ton in the case of the Haspe works, and the second position is occupied by the Rombach works with 12s. 3d. per ton, these being the other two works which do not own coal mines. On the other hand, the undertakings which control their own supplies of fuel exhibit very considerable differences in the gross profits per ton of steel made in 1908-09. Thus the accounts of the Rhenish steel works show gross profits of 12s. 4d. per ton; the Dortmund Union, 13s. 3d.; the Georgs-Marien Bergwerks, 18s.; the Hoesch works, 18s. 3d.; Aumetz-Friede, 18s. 9d.; the Bochum Verein, 20s.; Van der Zypen-Wissen, 20s. 4d.; the Guttehoffnungshutte, 23s. 6d.; Phœnix Works, 25s.; and the Deutsch-Luxemburg, 28s. per ton. These figures are reflected in the financial results which, with the exception of one undertaking which is still being financially fortified, show dividends for the thirteen remaining works which range from 4 to 20 per cent. for the year 1908 09, although these are mostly less than in the preceding year.

The figures quoted, while being incomplete in consequence of the different periods of termination of the financial years of other works, demonstrate the great advantage possessed by the coalowning iron and steel works over those which have no supplies of fuel at their own command, and it is, therefore, scarcely surprising to learn that one of the four deficient in the latter respect is now occupied in opening up a coalfield acquired for this purpose. The works which are the most favourably situated are those which, so to say, sit on the coalfields in Rhenish-Westphalia, whilst those situated on the iron ore mines in Lorraine and Luxemburg are less satisfactorily circumstanced unless they are associated with Rhenish-Westphalian coal mines, such as the Differdingen and Aumetz Friede works. On the other hand, certain undertakings in Westphalia are also interested in works in Lorraine and Luxemburg, and the coal supplies of the one complement the iron ore resources and blast furnaces of the other. Combinations of the latter class are already in existence, and that of the Gelsenkirchen Company at Esch and Deutsch-Oth, comprising nine furnaces, is to be increased by the addition of further furnaces and a steel works, and an entirely new blast furnace plant is to be erected at Maizières, near Metz, by the firm of Thyssen and Co.

These developments and other movements of a somewhat similar character are all intended to strengthen the undertakings concerned when the time arrives, either next year, or in 1911, for the attention to be given to the question of the renewal or discontinuance of the German Steel Syndicate in 1912; and it is, therefore, highly probable that in course of time the ordinary blast furnaces, which have just experienced an exceedingly unfavourable year, will either be commercially ruined or absorbed by the large combined iron and steel works having their own collieries, as well as iron ore mines in some instances, and capable of producing steel even at large gross profits per ton during a year of trade depression.

GERMAN COMPETITION IN STEEL.

(From a Correspondent.)

THE question of German competition in the iron and steel trade merits more than ordinary attention just now. It is but a matter of a few months when, at their present rate of progress, the Germans will get ahead of us in the exportation of iron and steel, and our long held supremacy in that line will be gone. It is time to take stock. Less than a dozen years ago we exported four times as much iron and steel as the Germans. Now our rivals have nearly drawn level with us in the race, and while we are merely marking time they are making substantial headway. Within quite recent years we have been relegated from the first to the third position as an iron country in point of production. Both America and Germany have got ahead of us. That is not unnatural, perhaps, for those countries have larger populations than Great Britain; but there is no natural reason why we should also be beaten in exports. Such is our manufacturing skill, such are our natural resources, and, above all, such are our geographical advantages that we ought to retain first place as an iron and steel exporting country without any difficulty. We can produce iron and steel better and cheaper, and we can ship the products more conveniently, than any other country. In neutral markets we ought easily to defy foreign competition, save in a few specialities. Besides, we depend so largely upon imported agricultural produce, and, consequently, so largely upon exports of manufactures, that it is essential that we should retain a larger share of the world's export trade in iron products than any other country. It will be a national misfortune, and it will be a national humiliation, if we lose first place in iron exports. That we are in danger of losing first place may be seen by a glance at these figures:—

Iron and Steel Exports from:—

	Great Britain. Tons.	Germany. Tons (metric).
1897	3,318,000 ...	768,000
1898	2,902,000 ...	847,000
1899	3,3?8,000 ...	777.000
1900	3,213,000 ...	838,000
1901	2,617,000 ...	1,410,000
1902	3,241,000 ...	2,126,000
1903	3,209,000 ...	2.199,000
1904	3.366,000 ...	2,770,000
1905	3,721,000 ...	3,349 000
1906	4 682,000 ...	3,666,000
1907	5,311,000 ...	3,455 000
1908	4,233 000 ...	3,732,000
1909 (first three quarters) ...	3,074,000 ...	3,089,000

These figures require explanation. It is time we faced the facts. While the world's demand for, and our rivals' production of, iron and iron goods are increasing rapidly, we are doing little or nothing to increase our trade in iron goods. Unless we wake up we shall soon be relegated to a mere fifth-rate position in an industry where we ought to reign supreme. Here we have Germany, a country labouring under natural, geographical, and economic difficulties quite unknown in this country, making great headway while we are standing still!

To begin with, Germany's minerals are neither so cheap nor so good, nor yet so conveniently deposited as ours. Here we have natural shipping facilities, iron ore supplies, coal and limestone, and manufacturing plants, all practically side by side; while in Germany the ore deposits are far removed from the coalfields, and both ore and coal, and, therefore, manufacturing plants, are at long distances from seaboard. While the average haulage distance for iron and steel making materials in Britain is less than thirty miles, in Germany it is not less than 150 miles. In this country it costs in few cases more than about 1s. 6d. per ton to carry ore, or more than 2s. to 3s. per ton to carry coal to the smelters; while in Germany it costs between 6s. and 7s. per ton for assemblage charges. Then, again, the prime cost of Germany's coal is considerably higher than ours. Even if we did not possess an ounce of iron ore in this country, our coal supply is such, and our geographical situation is such that we could easily beat Germany in the iron trade. We can fetch the very best Spanish and Scandinavian ores and land them right alongside our blast furnaces, in the very heart of our best coalfield, at a much less cost for freightage than the Germans can carry their own domestic (and inferior) ore from mines to furnaces. Besides, not only does it cost Germany more for mining and assemblage charges, but after the furnaces have turned out their products, those products, if for export, have to be conveyed nearly ten times as far to a port of shipment in that country as is the case in Britain. And yet Germany is threatening to dislodge us from the first position as an iron exporting country.

Of course, Germany's industrial progress is frequently attributed to cheap transit, cheap mining royalties, and cheap labour. But in competition with Great Britain, it is not strictly accurate to contend that Germany's iron trade is favoured under these headings. That mining royalties do not count for much is proved by the fact that the pitmouth price of coal is higher in Germany than here. That cheap transit does not count for much either has already been explained in connection with Germany's long haulage distances, which completely destroy the alleged advantage of low ton-mile rates. Nor does the German iron industry hold any advantage over the British industry in the matter of cheap labour. Nearly fifteen years ago the British Iron Trade Association delegates to Germany, after visiting the leading iron and steel works there, expressed their "surprise" at finding how very nearly the wages of the German workers approached those of our workers. Mr. J. Stephen Jeans, the secretary, declared that "in not a few cases" the wages for similar classes of work in the two countries "were practically on all fours." Since then wages in the skilled trades have gone up by 22 per cent. in Germany against 11 per cent. in Britain, and unskilled wages have risen by nearly 50 per cent. in Germany against no rise at all in this country. Wages per worker employed, and per unit of output, are actually higher in the iron group of trades in Germany than in Britain. No; Germany's success in the iron and steel trade is not due either to cheap labour or superior natural resources—it is not due to any fundamental advantage over this country.

What, then, is the secret of German success? The reply can be given in one word—organisation. Without its vast system of syndication—its almost military-like productive and distributive methods—and the organised fostering of export trade by bounties, the German iron industry could not possibly have attained its present status. The production, price, and sale of practically every material and article of iron manufacture, from coal and ore to wire nails, are controlled by some syndicate or manufacturers' union. A German syndicate does not, as a rule, control or own any works as do the American "trusts," but only the products of the works. Thus a German firm manufacturing a dozen different articles may be a member of a dozen different syndicates, and not a unit of a single trust. The usual syndicate system is for a number of experts to visit each of the works and ascertain its capacity of production and aptitude for any special line of business. Then orders, which are generally received by the central offices, are allocated to the various establishments, regard being paid to the geographical situation and mechanical equipment of the several firms in order to effect every possible economy. For example, a Russian or Austrian order would, other things being equal, be allotted to a Silesian works, while an English or or French one would go to a Westphalian firm. The whole country is mapped out into trading zones, and if, after careful allocation of orders, any firm is placed at undue advantage in the matter of transit, &c., it is compensated to the extent of the extra carriage. Payments as well as orders usually pass through the central offices, and the syndicate attends to many trade, legal, and other affairs in the interests of its constituents. These German syndicates are manufacturers' trade unions and co-operative societies combined.

In 1897 some of the German iron trade syndicates inaugurated the export bounty policy, and it is this agency which has been mainly instrumental in promoting German competition with this country. The coal, coke, pig iron, and steel syndicates controlling raw materials agreed to supply their associated customers—the iron and steel manufacturers and engineers—with fuel, iron ingots, &c., at cheaper rates when such materials were needed to manufacture for export than when required for the home market. From time to time the bounty rates, or rebates, have been increased or decreased in response to the fall or rise in the home demand. If the home demand has been brisk the bounties have been low; if it has slackened, up have gone the bounties in order to promote exports. Thus we have had the spectacle of Germany doing the most trade abroad when there has been the smallest volume of trade available. Between 1897 and 1905, when the bounties were in practically constant operation, German exports, contrasted with our own, made the following progress:—

Iron and Steel Exports from:—

	Britain. Tons.	Germany. Tons (metric).
1897	3,318,000 ...	768,000
1905	3,721,300 ...	3,349,000

Early in 1906, however, so vigorous had Germany's home demand become, and so good were prices abroad, that the need for export bounties and dumping ceased. The bounties were first reduced and then suspended, and then we got these figures:—

	Britain.	Germany.
1906	4 682 000 ...	3,666,000
1907	5,311,000 ...	3,455,000

During 1908 and most of 1909 there has been depression. Early last year the bounties were reintroduced, and now we get this result:—

	Britain.	Germany.
1908	4,233,000 ...	3,732,000
1909 (first three quarters) ...	3,074,000 ...	3,089,000

The contrast is striking. In 1908, compared with 1907, Germany increased her exports by 277,000 tons, while ours declined by 1,078,000 tons, and in the first nine months of the current year, compared with the corresponding period last year, while our exports have dropped by another 35,000 tons, those of Germany have risen by 91,000 tons. Our rivals, who are organised, are getting a larger share of the world's trade. We, who are not organised, are getting a smaller share. The lesson is plain and unmistakable. We must organise or be beaten.

LITERATURE.

Electricity. By H. M. Hobart, B.Sc. London: A. Constable and Co., 10, Orange-street, Leicester-square.

A RAPID glance at the illustrations contained in this book is sufficient to show that it differs very materially from most others having the same title. Indeed, it may be said that the volume possesses that desirable but unusual feature—originality. The author has deemed it unnecessary to instruct the reader to procure a stick of sealing-wax and to rub it with a piece of dry flannel or fur. He has considered it expedient to omit all reference to glass rods, electroscopes, Leyden jars, or pith balls. There is not even the slightest trace of anything about Wimshurst's machine, the electrophorus, or Faraday's reversible net, nor is the reader told that if he vigorously rubs the household cat's back he will see sparks—instructive as that experiment is liable to prove. All these things, whilst of interest from a historical standpoint, are of little value to the present generation of electrical engineering students, and it is refreshing to find an author of a book on electricity who recognises this fact. It must, we feel sure, often come as a tremendous surprise to youths who, after having studied that fascinating subject known as frictional electricity, suddenly find that few of the things they have read about have any relation to present-day conditions, and that the electric lighting of our houses and streets, the propulsion of electric trains and tramcars, and the numerous other commercial applications of electricity are in no way dependent upon the invention of Wimshurst's machine, and that electricity is not stored for commercial purposes in Leyden jars.

The first chapter of the book is entitled "The Generation and Conduction of Electricity," and here the author naturally has to explain that electricity is not generated at all, and his remarks in this connection are unique. He says that it is convenient and justifiable to speak of generating electricity, just as we speak of making cake when by suitable agency we transform material substances, such as eggs, flour and milk, into the material substance which we term cake. It is not clear why Mr. Hobart does not adopt the common method of explaining that electricity is not generated, by asking the reader to regard the so-called generators of electricity as electric pumps which set up a potential difference between the ends of the circuit, and so cause electricity which already exists to flow through the conductors constituting the circuit, for whatever objection may be raised against this explanation, it at least has the effect which Mr. Hobart

desires of causing the student to lose the idea that electricity is generated.

Some instructive information is given in the second chapter concerning copper, aluminium, and other conducting materials, and following this there is a chapter on energy, wherein the author states that he finds it helpful to think of energy as the life of matter. Before going further, we should mention that throughout this treatise the author in making calculations employs a comma instead of the usual decimal sign. We have not been able to discover the object of this, and we cannot think of any advantage which the practice is likely to have. On the contrary, it is liable, until the reader becomes familiar with the system, to lead to confusion. For example, if one meets with 1,173, a certain amount of thought is at first necessary to decide whether it means one thousand one hundred and seventy-three or one, decimal one seven three, notwithstanding the fact that if it were the former the printer would probably leave out the comma. Many instances occur throughout the book where the author's use of words and terms deviates from that accepted by the physicist. Of this, the preface tells us, the author is well aware, but it is considered useless to oppose beyond a certain point the popular will as regards the use of words. In this connection, it is pointed out that the so-called consumer of electricity really pays for energy, but he calls it electricity, and this meaning of the word has also gradually come to be adopted by engineers. Mr. Hobart does not appear to be a believer in water analogies, for even in his chapter on Ohm's law none of the familiar diagrams employed for illustrating the fall of potential in a circuit are to be found. In this part of the book he gives some curves showing the temperature rise of bright conductors of circular section in still air at 20 deg. Cent. for various diameters; also some curves showing the current required to fuse wires of various sizes and materials. A chapter on the magnetic field contains some information which the student will find well worth acquiring, and the same applies to that section of the book which deals with conductors moving in a magnetic field. The alternating current section is also good, and in a number of places it possesses the merit of originality. For example, in one instance where the familiar right-angled triangle is constructed, to represent the resistance, reactance, and impedance of a circuit, in order to give the reader a useful mental conception of the case, the lines representing the resistance and reactance components are broken in the centres. Across the gap in the resistance component a non-inductive resistance is shown, whilst across the other gap there is a choking coil. Many simple but useful calculations are made in this section of the book, and those students who have been unable to understand what power factor means should be out of their difficulty after having read the latter part of Chapter IX. Professor Kapp's innovation of designating as the "crest" value the maximum instantaneous value of an alternating pressure or current has been adopted in this book.

The last section is devoted to insulating materials, and here again some useful information is given both in text and graphic form. The book, as we have already intimated, is written on practical lines, it contains nothing which is particularly difficult to understand, and, all things considered, it is a decided improvement on most books we have seen having for their title the word "Electricity."

SHORT NOTICES.

Laboratory Notes on Iron and Steel Analyses. By W. Macfarlane, F.I.C. London: Longmans, Green and Co. Price 7s. 6d. net.—This book treats very fully of the chemical analyses and details associated therewith of iron and steel, and covers most of the work of the chemist at a steel works or blast furnace. The author writes with a long experience of his subject behind him. The notes from which the present work was prepared were orginally composed for the guidance of the laboratory staff of an iron and steel works, and have since been found useful to the students in the laboratory at the Wednesbury Metallurgical Centre. It has, therefore, already had a wide test as regards the trustworthiness of its matter, both as a practical and as an educational work, and we can recommend it for its clear style of exposition. Everything is done to simplify the analyses and to economise the chemist's time. As an example, we would point to the arithmetical details associated with each analysis. In all cases the combining weights are given and the formulæ reduced to their lowest expression, and to facilitate the final calculation of place logarithms are given for the known figures entering into the result.

Machine Shop Drawings. By F. H. Colvin. London: Hill Publishing Company, Limited. Price 4s. 6d. net.—This book is intended to give its readers a good working knowledge of shop drawings and to enable them to become expert at "reading" them. It is American in origin, and resembles many other volumes of a "practical" nature coming from that country and now on sale in this. That there is a demand for such works in their native land is shown by their increasing number. With us, however, we doubt if many workmen will be induced to pay 4s. 6d. for a work which, after all, contains very little that cannot be picked up casually during the first year of apprenticeship in the shops, while many of the details in it are wholly American and not applicable in this country. To apprentices the book can scarcely be recommended in place of the ordinary work of the machine design class, while to draughtsmen the work is, or should be, superfluous.

BOOKS RECEIVED.

Deutscher Kalender für Elektrotechniker, 1910. By G. Dettmar. München, Germany: R. Oldenbourg. Price M. 5.

Hennebique Ferro-concrete Theory and Practice. London: L. G. Mouchel and Partners, Limited, 38, Victoria-street, S.W. Price 10s. 6d. net.

THE DETECTION OF FIRE-DAMP.

THE study of the significance of the "cap" or halo which surrounds a flame burning in an atmosphere containing inflammable gas has been taken up by eminent men from time to time ever since the invention of the safety lamp, but until it was definitely proved that the ignition of coal dust in a mine could, under certain circumstances, cause an explosion, and that the presence of small percentages of gas greatly increased the possibility of such ignition, mining men did not attach any great importance to recognition of "caps" which indicate these small percentages. The fact that these small amounts of fire-damp, though much below the proportion necessary to form an explosive mixture of the gas and air alone, could, in the presence of dust become dangerous, once recognised, a number of devices for the detection and estimation of the proportion of fire-damp were introduced.

In order to render the pale blue "cap" more visible, the user of a safety lamp reduces the flame until only the

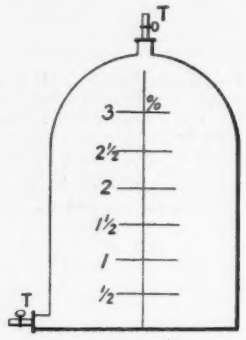


Fig. 1—GASHOLDER

darker blue and nearly non-luminous portion of the flame is visible. Several of the devices referred to therefore used the non-luminous flame of hydrogen or alcohol, with the further advantage that the greater heat of these flames, as compared with that of the ordinary safety lamp flame, gave a much larger and more distinct "cap." Perhaps the best example of the former type is the Clowes device, which consists of a small cylinder of hydrogen attached to the lamp, and provision for burning a jet of this gas inside the lamp. The Pieler lamp is a good example of the alcohol type. An arrangement depending on the increased "glow" of a heated platinum wire in the presence of inflammable gas has also been introduced.

Most of these arrangements, however, are adapted for the use of experts only, and might even be dangerous in

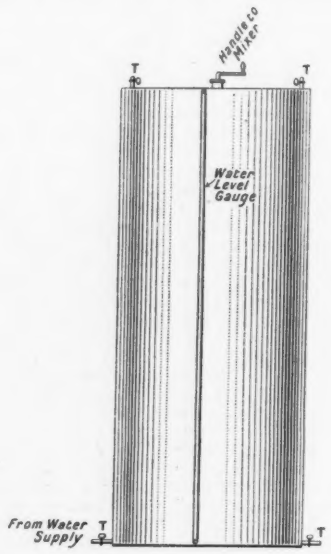


Fig. 2—MIXING CHAMBER

other hands. Estimations and tests made by experts, and communicated to the man who must put the results into practice, cannot be as useful as the men's own observations, if means are found to enable them accurately to assess the percentage value of the "cap." The "cap" or halo, which indicates the presence of inflammable gas, being of a pale blue colour shading into a still paler greeny blue, may be unrecognisable to a man whose colour perception is below normal. From the report of the Commission on Safety in Mines it is evident that the reports of mines inspectors and the evidence placed before them impressed the Commissioners with the necessity of ensuring that the man on whom the duty falls should not only be able to see the "cap," but should be able to put a true value on that "cap."

The man on whom this duty falls, in British coal mines, is the "deputy" or "fireman" who is required to make certain daily tests with the object of ascertaining the presence or otherwise of gas in the workings under his charge. He is also the main source of information available to the management as to the state of the mine. The Commission recommend that this official—who need not at present hold any certificate—should be required to obtain a "certificate from a mining school or other place approved by the Secretary of State as to his ability to make tests for fire-damp."

The apparatus, designed by Mr. Winstanley and exhibited by him at a recent meeting of the Manchester Geological and Mining Society, would seem to provide the means of giving the instruction necessary and of testing the man's ability to make tests for fire-damp. It certainly appears to mark a distinct advance in the means available for the study of fire-damp "caps"—particularly from the standpoint of the practical man.

The apparatus consists of a gas holder—Fig. 1—a mixing chamber—Fig. 2—and an ordinary "safety" lamp—Fig. 3—arranged to take all its supply of air from the mixing chamber. The gas holder is a glass aspirator with necks for tap connections—T, T—at the top and bottom. It is carefully calibrated into divisions equal to $\frac{1}{200}$th ($\frac{1}{2}$ per cent.) of the capacity of the mixing chamber. The mixing chamber is a copper vessel provided with

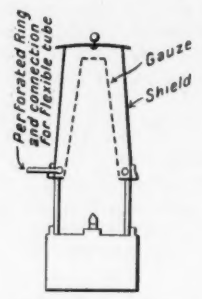


Fig. 5—SAFETY LAMP

the necessary taps and connections—T, T—a water-level gauge and a simple mixing arrangement. The mixing chamber is first entirely filled with water and the bottom of the chamber connected, by means of short tubes, to the bottom of the gas holder, the tops of the two vessels being similarly connected. If it is desired to have a 2½ per cent. mixture of the gas and air, water is allowed to flow from the chamber into the gas holder up to the division representing that percentage, displacing an equal volume of gas. The connections between the two vessels are now closed, and air is allowed to take the place of the remaining 97½ volumes in the mixing chamber, which now contains a 2½ per cent. mixture of gas and air. A simple arrangement insures the thorough mixing of the two, and by again slowly admitting water to the chamber a sufficient supply of the mixture to keep a safety lamp burning for about an hour is obtained. The only modification required in the lamp, which must be of the bonneted or shielded type, is the closing of the ordinary inlet holes, and the addition of a perforated ring tube encircling the gauze, inside the shield, which delivers air or a mixture of gas and air at the point where air would otherwise enter in the ordinary way. This pipe being connected to the mixing chamber the lamp must burn in an atmosphere, the composition of which is determined by the adjustment of the mixture in the chamber.

In the lamps in use in British coal mines, three illuminants, or classes of illuminants, are in use—colza or rapeseed oil with the admixture of various proportions of mineral oil, colzalene, and similar substances, and mineral oil. Each of these illuminants will give a "cap" of different appearance when burning in the same percentage of gas, so that a man must be able to see for himself the appearances presented by "caps" on the flame of the lamp with which he is to work in the mine when burning in known proportions of gas and air. This the apparatus described above would render possible. The main advantage is that the observer is not guided by descriptions or dimensions depending on the observation of someone else, whose colour perception may differ materially from his own, but is able to note for himself the changes in the appearance of the "cap" in varying but known proportions of gas. Having once learnt the significance of the various "caps," he should be in a position to make sufficiently accurate tests of the presence or otherwise of gas in the mines; and, if present, to estimate the proportion which the particular "cap" shown represents.

KING'S COLLEGE (UNIVERSITY OF LONDON).—In connection with its Faculty of Engineering, a special course of lectures on "Irrigation Works" will be given by Mr. N. F. Mackenzie, M. Inst. C.E., lately Under-Secretary for Irrigation to the Government of India, on Thursdays, at 5.15 p.m., commencing on January 13th. Another special course of lectures on "Reinforced Concrete" will be given by Professor H. M. Waynforth, Assoc. M. Inst. C.E., M.I. Mech. E., on Wednesdays, at 5.30 o'clock, commencing on January 19th, 1910. Another special course of advanced lectures and demonstrations on "Single-phase Electrical Traction" will be given by Professor Ernest Wilson, M I.E.E., and Mr. Francis Lydall, commencing on Monday, January 17th, 1910, at 5.30 p.m

THE INSTITUTION OF CIVIL ENGINEERS: STUDENTS' MEETINGS.—At the students' meeting held at the Institution on Friday, the 17th December, at 8 p.m., Mr. J. M. Dobson, M. Inst. C.E., in the chair, a paper was read by Mr. H. T. Tudsbery, Stud. Inst. C.E., on "The Foundation and Construction of Dock Walls: with special reference to recent work at Southampton." The author, having discussed the conditions governing the design and construction of dock undertakings, dealt with the survey and preliminary works. In the second part of the paper, the construction of walls built in the dry, concrete-block walls and pier and arch walls was described. The concluding portion of the paper was concerned with cement and concrete. The paper was followed by an interesting discussion in which the following students took part:—Messrs. A. J. Hart, E. Timothy, G. F. Walton, N. Smith, R. A. Inglis, M. W. Pretyman, R. J. Samuel, and P. G. Bowie.

LEAD TRAP PRESS

J. PHILLIPS AND CO, BERMONDSEY, ENGINEERS

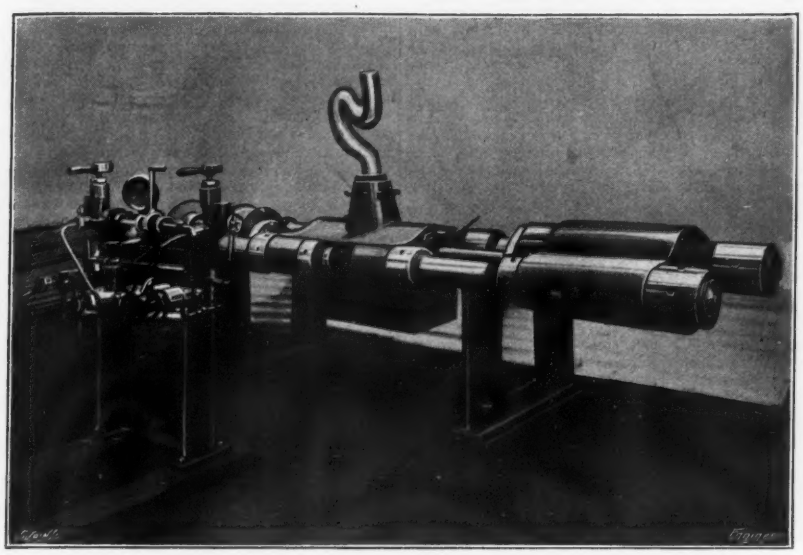


Fig. 1

A LEAD TRAP PRESS.

WE were recently afforded an opportunity of inspecting a press for the manufacture of lead traps which has been built by J. Phillips and Co., of Salisbury-street, Bermondsey, to the order of a continental firm. With this machine, which is shown in Fig. 1, several sizes of traps can be made with the same head in position. At the time of our inspection the press was in operation making traps with very narrow curves. These were produced with great ease. In accordance with the usual practice, the press has two double-acting hydraulic cylinders, operated by means of the pump shown in Fig. 2. The trap-forming head is clamped between two crossheads in the usual manner, and the lead rams are bolted to those of the hydraulic cylinders. To charge the press the lead rams are drawn out of the lead containers until the charging ports, cut in their ends, are uncovered, and the molten metal is then poured into these ports. When

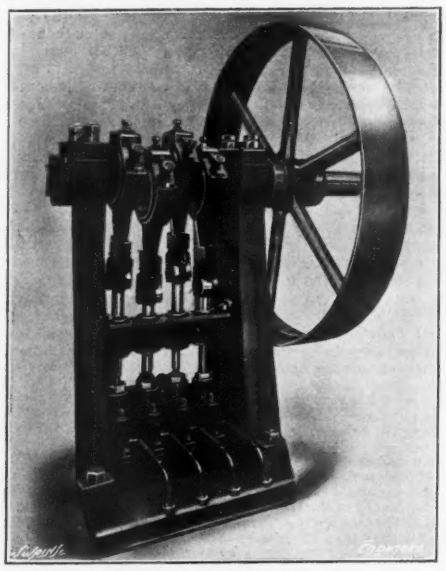


Fig. 2—HYDRAULIC PUMP FOR LEAD TRAP PRESS

the hydraulic rams are subjected to equal pressures, the metal is forced up through the centre head, and a straight pipe is formed, but by subjecting one side of the press to a greater pressure than that on the other side a bend is formed in the pipe.

By means of valves shown mounted on a stand in front of the press, the hydraulic pressure is under such perfect control that any bend or any angle can be obtained. Gas jets are provided under the centre head, by means of which the molten metal is maintained at the correct temperature. The head in the centre of the machine can easily be removed when necessary; but, as already mentioned, several sizes of traps can be made with the same head in position, the variation in size being obtained by merely changing the dies. In all eight sizes of traps can be made on this press, these sizes ranging from 1in. to 4in. in diameter. The pipe for each of these sizes can also be made in four different thicknesses. It should be mentioned that the firm builds these presses for any class of duty, and for making traps or bends on one or more planes.

HIGH-SPEED PNEUMATIC HAMMER.

THE demand which exists for a pneumatic hammer capable of working at high speeds, which can be set to run automatically with various strengths of blow, has induced the firm of Peter Pilkington, Limited, Bamber Bridge, to produce the design shown in the accompanying illustrations—Figs. 1 and 2. The principle on which the hammer works is identical with that of the ordinary forge type, as described in THE ENGINEER of July 19th, 1907. The air cylinder is of considerable length, bored out to two diameters, and at the upper end of the tup there is formed a piston head, working in the upper or larger power cylinder, while the smaller cylinder acts as a guide. Air is admitted under the piston into the upper cylinder for lifting the tup only, and this same air on being exhausted is expanded on the top side of the piston for striking ordinary blows. When a heavy stamping blow is required, the operator can utilise the full air pressure on top of the piston. It should be pointed out, however, that for striking dead blows the lifting area of the

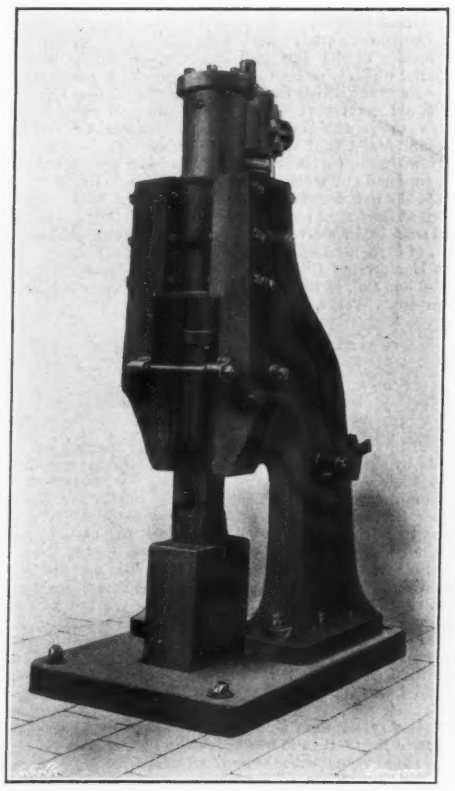


Fig. 1—AUTOMATIC HIGH-SPEED PNEUMATIC HAMMER

piston is in communication with the air supply, as well as with the space on top of the piston, or, in other words, both sides of the differential tup are in communication with the air supply.

In the ordinary pneumatic hammer made by this firm there is only a single operating lever, which serves for all strengths of blow, light or heavy, and also for holding up or down. In the high-speed type illustrated there are provided two levers, one to give the time blow, and the other to fix the automatic blow for any degree of intensity. The self-acting motion consists of the quadrant lever A, which is rigidly connected to a crank or movable fulcrum pin B. This supports another lever C, carrying a roller D at the end, which also operates the piston valve E. When the quadrant lever is in its lowest position—shown in full lines—the movable fulcrum pin will be in its highest position, so that when the air pressure is turned on the tup will rise, and the lever carrying the roller will also rise on the inclined slide F. The piston valve will thus be raised, allowing the air to flow to the top side of the piston, when the tup will be driven downwards. This cycle is repeated automatically so long as the air supply valve is open. When, however, the quadrant lever is moved to its highest position—shown in dotted lines—the fulcrum pin is brought to its lowest position, and this lowers the lever and the piston valve. In this case the air is again admitted to the lower side of the piston, and the tup rises to its top position; the inclined slide again lifts the lever and valve, but since the latter was lowered by the quadrant lever, the valve will not be raised to the same height as previously, and the port to the top of the piston will remain closed. The tup therefore remains in its highest position. When it is desired to operate the hammer by hand, or to strike dead blows, it is only necessary to operate the hand lever C, and thus move the valve, the quadrant lever in the meantime

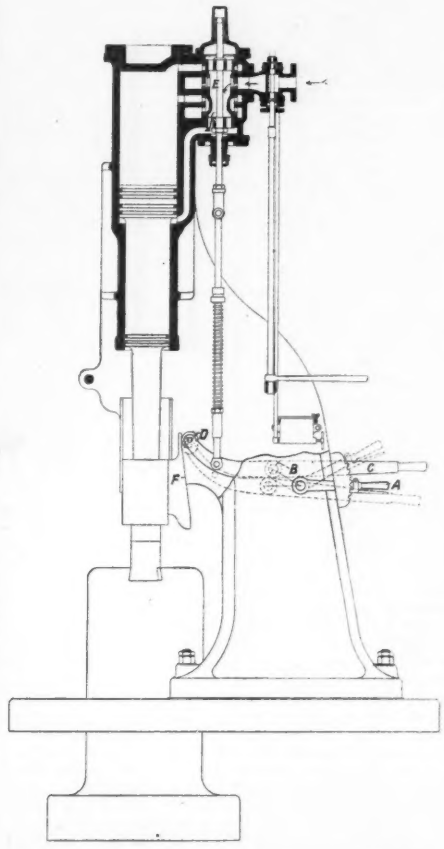


Fig. 2—SECTION THROUGH CYLINDER OF HAMMER

being fixed in its highest position. The force of the blow when the hammer is working automatically is thus regulated by varying the position of the quadrant lever.

Attention should be called to the method of securing the cylinder between the two standards, the cylinder being provided with two keys, which form part of the cylinder flanges. These keys fit into corresponding recesses in each standard, and take the shear off the bolts which hold the parts together. This type of hammer is made in sizes varying between ¼ cwt. and 7½ cwt., and the number of strokes per minute varies between 300 in the smallest to 150 in the largest sizes.

USE OF ELECTRICITY IN MINES.—The Council of the Institution of Electrical Engineers are considering the evidence to be submitted to the Home-office in connection with the inquiry on the use of electricity in mines. The secretary of the Institution will be glad to receive in writing, on or before January 10th next, any observations which members may wish to make on the Special Rules of the Home-office for the Installation and Use of Electricity (Coal Mines Regulation Act, 1887) now in force.

INSTITUTION OF ELECTRICAL ENGINEERS—GLASGOW SECTION.—At a meeting of this body held in the Institution Rooms on December 14th, a paper was read by Mr. W. Arthur Ker on "Continuous Current Boosters and Balancers." Dealing first with two-wire supplies, the author said that for a small town the generating station was often placed near a railway or canal, in order to obtain cheap coal, or to get water for condensing purposes, and that in consequence it was usually at some distance from the consumers, and a feeder or feeders became a necessity. With a healthy growth of the demand a time came when it was necessary to equalise the voltage on the system, as the consumers at the far end got too low a pressure, while that of those nearer the station got too high. The natural method was to lead a two-wire feeder to the mid-point of the network, either keeping the original two-wire line to the town as a second feeder or disconnecting it. Assuming that it was disconnected, there would then be the network supplied by one feeder at its middle point, and it would be possible to regulate the voltage at the feeding point by shunt regulation of the dynamo. As, however, by that time two or more dynamos would be required to supply the demand at times of heavy load, it might be better to put in a booster to compensate for the drop in the feeder and to keep the bus-bar voltage constant. Such a booster might be driven by an electric motor, by a belt, or by an engine, and it might consist of a single-shunt or series-wound generator. If shunt-wound, it would require to be regulated by hand, and with unsteady loads, such as might occur in a small town, hand regulation was not satisfactory. A series-wound booster which required no regulation would therefore be installed. This was, the author explained, the cheapest type of booster, and was quite satisfactory, so long as there was only one feeder, but it could not be used in conjunction with another small booster and feeder, unless certain precautions were taken. Though there were only some twenty stations in the United Kingdom employing two-wire distribution, the author said he had thought it advisable to deal with two-wire boosters somewhat fully, as explanations were more easily made in connection with a two-wire supply than with the more complicated three-wire supply. He then proceeded to deal at considerable length with three-wire boosters, referring also to the use of balancers. A discussion followed.

NAVAL WORK ON THE CLYDE.

OFFICIAL news of the definite ordering by the Admiralty of the four powerful warships which were made supplementary to the year's ordinary programme, although yielding to the Clyde centre much less than that which local notions of equity suggested, and fond rumour had anticipated, has been received on the whole with thankfulness. The order received by William Beardmore and Co., of Dalmuir, to construct and engine one of the three super-Dreadnoughts has caused, in the Dalmuir district at least, the liveliest satisfaction, where work, either naval or mercantile, has for long been at the lowest ebb. What with the order for the "Improved Bristol" cruiser received two months ago, and the outfitting work proceeding on the cruiser Gloucester, sent afloat on October 28th last, there is at least something to show for the calling into being of the great Beardmore naval establishment, which as yet has only fully to its credit one big naval unit, the Agamemnon. In her case the machinery was supplied by a Tyne firm, whereas the turbines for the battleship just ordered will be completed by William Beardmore and Co. themselves. In this connection it may be stated that the turbines for the cruiser Gloucester were seen working under steam in the shops of the Dalmuir establishment on the occasion of the recent visit of the Chinese Naval Commission. The new ship, like its sisters just ordered, is 6000 tons heavier than the Agamemnon, 4600 tons heavier than the Dreadnought, and 2000 tons heavier than the Dockyard-built Neptune. The new vessels are 120ft. longer and 10½ft. broader than the King Edwards, and all the fighting elements have been proportionately increased.

The addition of this ponderous super-Dreadnought to the volume of naval tonnage on hand emphasises what has already been recognised regarding the present state of the shipbuilding industry on the Clyde. At no previous period in its history has there been such a large proportion of the work on hand destined for naval purposes. This is certainly so as regards the number of vessels, and probably it is no less true as regards aggregate volume of tonnage. Much is no doubt wanting, as regards mercantile tonnage, to approximate to the normal working capacity of the shipyards, but the district has little cause to complain as to the extent to which it has participated in the naval work given out to contract by the Admiralty. There is, in addition, quite a considerable amount of naval work on hand for other Governments, *e.g*, Brazil and the Australian Commonwealth. No fewer than seven different shipyards between Greenock and Govan are at present engaged on, or have on their books, British naval contracts, the work embracing two first-class battleships of the Dreadnought class—the Colossus on the stocks of the Scott Company, Greenock, and the vessel just ordered from the Beardmore firm—five second-class cruisers of the "Bristol" and "Improved Bristol" class, and no fewer than fifteen torpedo-boat destroyers. Including the five destroyers on hand for Australia—three at Fairfield and two at Messrs. Denny Brothers, Dumbarton—and the four which Messrs. Yarrow and Co. have still to complete for Brazil, there is a total of twenty-four destroyers under construction or completing their outfit in the Clyde district.

In view of this unusually large amount of naval work under construction or afloat being outfitted, some reference to the records of warship-building on the Scottish river may here not be without interest. In a paper by Professor J. H Biles on "Fifty Years of Warship-building on the Clyde," read before the joint Conference of the Institution of Engineers and Shipbuilders in Scotland and the North-East Coast Institution in August last, a number of statistical tables on this subject were given, from which the following notes are abstracted. The first table dealt with the displacement tonnage of British warships constructed in Clyde shipyards during the five decennial periods beginning 1858 1868, and ending 1898-1908. In the first period, out of a total of 110,496 tons, the Clyde's share was 15,920—just about the tonnage of a modern cruiser. During the ten years beginning 1868, the Clyde produced 53,770 tons out of a total of 235,555 tons, while in the next period the naval productions of Clyde shipyards amounted only to 86,090 tons, although the total addition to the Navy during that time had increased to 255,872 tons. A remarkable advance was made by the Clyde, however, in the decennial period 1888-1898, the total output being 168,069 tons out of a total of 875,060 tons. In the last period dealt with—1898-1908—the Clyde made another notable advance, her contribution to the Navy representing 272,390 tons out of 1,063,430. From these figures it will be observed that the Clyde made an advance of no less than 104,180 tons in the last decennial period, while the total increase to the whole Navy, compared with the previous ten years, was only 188,370 tons. Reduced to percentages, the Clyde's share of the tonnage built for the Royal Navy during these same years has fluctuated as follows:—1858 68, 13 per cent.; 1868-78, 23 per cent.; 1878-88, 14 per cent.; 1888 98, 19 per cent.; and 1898 1908, 26 per cent.

The London and Glasgow Shipbuilding and Engineering Company, Limited, Govan, which was commissioned by the Admiralty about the end of October to build one of the second-class cruisers of the "Improved Bristol" type, is making good progress with the 27-knot torpedo destroyer, the order for which was received about the beginning of the year, and, as little else is at present on the stocks, no time is being lost in proceeding with the preliminaries of the actual construction of the cruiser. The turbine machinery for this vessel, it should be stated, is to be supplied by John Brown and Co., Limited, Clydebank.

For an extension to its working area, as well as to provide the site for a tidal basin in which to complete the outfit of naval and mercantile vessels of the largest size, the London and Glasgow Company has acquired the vacant shipyard adjoining, formerly and for long occupied by Messrs. Robert Napier and Sons, and by their successors, Wm. Beardmore and Co.—who took over the business in 1900—until the latter's removal to Dalmuir early in 1905. It is of interest to recall that the ground now about to be absorbed by the London and Glasgow Company was first used as a shipyard in 1841, when Robert Napier added iron shipbuilding to his already extensive engineering business. Previous to being taken over by Messrs. Wm. Beardmore and Co. in 1900, there had been built at the yard thirty-four warships of different types, while the firm had at that time on the stocks two armoured cruisers, which were completed by Messrs. Beardmore.

The London and Glasgow Company's new basin will be situated in a very convenient position so far as its shipyard is concerned. The engine works are, as is well known, in Lancefield-street, farther up on the other side of the harbour. The shipyard department will extend over a riverside frontage about double that of the present works, and the new dock will be close to the Clyde Trustees' graving docks, and within a very short distance of those parts of the harbour where new vessels are usually berthed when they are not at their builders' works. With the steadily increasing size of ships, both naval and mercantile, the fitting out basin was absolutely necessary for the further development of the business. The river is sufficiently broad opposite the works to provide launching facilities for the largest class of vessels, and with a basin in which these may be completed the firm will be as well situated for all kinds of work as those much nearer the open sea. In order to be better able to compete for the construction of turbine machinery and large reciprocating engines, the company has been converting the erecting shop at its engine works—on the opposite side of the Clyde—into a more modern machine and fitting shop, and it has utilised some vacant area on the east side of the works for the building of a new erecting shop. These several extensions and alterations are in a forward state of progress, and when completed will enable the company to carry out important contracts with more despatch and economy.

The Fairfield Company, Govan, which was at least in the running as regards price—and ability to accomplish—for the super-Dreadnought which has conditionally gone to the Thames Iron Works, has a fair amount of Admiralty work on hand. In its tidal basin the outfitting of the cruiser Glasgow, launched on September 30th, proceeds apace, and of the goodly amount of tonnage on the stocks, eight items are torpedo destroyers, five for the British Admiralty and three for the Australian Commonwealth. Two of the five boats for the Admiralty are the 27-knot craft ordered near the end of last year, one—the Grasshopper—having been launched in November.

John Brown and Co., Clydebank, to which firm rumour had assigned the super-Dreadnought which subsequent and more official information gave to Messrs. Beardmore, are shortly to launch the second-class cruiser Bristol, and they have already consigned to the water three torpedo-boat destroyers ordered a year ago—the Beagle, Bulldog, and Foxhound, the latter being launched on December 11th in the presence of the Chinese Naval Commission. In its engine works the firm has a large amount of naval work, including the turbines of 43,000 indicated horse-power for the armoured cruiser being constructed at Devonport, as also the turbines sub-contracted for with Messrs. Harland and Wolff, Belfast, for the battleship being built at Portsmouth.

This week there was despatched from Glasgow *vid* the Caledonian Railway *en route* to the South of England the second 12in. naval gun manufactured at the new gun shops of William Beardmore and Co., Limited, Parkhead. This gun, like the first, completed some months ago, is of the largest type used by the heaviest battleships and cruisers in the British Navy. After being fitted with breech mechanism it will be subjected to the testing process, and eventually find a place in the armament equipment of one of the latest warships. The new gun, it is understood, embodies some departures introduced by Rear-Admiral Adair, the chief of the Ordnance Works at Parkhead, having for their object the prevention of the defect of drooping, or deflection of the muzzle, which is understood in naval circles to have attached to some of the earlier examples of the fifty-calibre 12in. gun. It would seem that the Admiralty are now allowing fuller scope to private ordnance manufacturers for bringing ingenuity and skill to bear on the work of their hands.

Now that important contracts have been definitely booked for guns and gun mountings by the Coventry Ordnance Company, the new works of the company which have been laid down at Scotstoun for the manufacture of gun mountings, will soon be in active operation. Messrs. John Brown and Co., of Clydebank and Sheffield; the Fairfield Shipbuilding and Engineering Company, Govan; and Messrs. Cammell, Laird and Co., of Birkenhead, are directly interested in the Company's Works.

SUBMARINE SIGNALLING.

DURING the past few years considerable progress has been made by the Corporation of Trinity House in introducing into their service submarine signalling for the guidance of the mariner in thick or foggy weather. In 1905 and 1906 the Elder Brethren carried out a series of experiments with a view to testing the system, and for the purpose a standard equipment, as supplied by the Submarine Signal Company of Boston, United States, was installed on the North Goodwin Light Vessel, in connection with which one of their receiving apparatuses was fitted on one of the Trinity House steam vessels—the Irene. Tests were made during those years by various Committees of the Elder Brethren, accompanied on some occasions by Lord Rayleigh, their scientific adviser, by Sir Thomas Matthews, their engineer-in-chief, and the officials of the Submarine Signal Company, and their reports as to the efficiency of the bell were so satisfactory, as were also those received from the masters of different liners, that it was decided to fit two of the Corporation's light vessels with the apparatus permanently. Hence on the 18th November, 1907 submarine bells were brought into operation at the Royal Sovereign and the Tongue, and shortly afterwards at the Outer Dowsing and the East Goodwin, since when they have been in action during foggy weather. The results were so promising that consideration was next given to the question of simplifying the mechanism of the bells, which are actuated by the air compressing plant fitted on board Trinity House light vessels for operating aerial fog signals. Certain alterations were accordingly made at the suggestion of Sir Thomas Matthews, the effect of which was to cheapen considerably the cost of manufacture, and bells of the modified design were placed in March of the present year at the Spurn, Outer Gabbard, Owers and Shambles, and quite recently at the Nab and St. Goven.

The Trinity House also turned its attention to applying this system of fog signalling to buoys, and a buoy fitted with a bell, on the Submarine Signal Company's patent, was fixed near the Nab Lightvessel for experimental purposes, the results being most satisfactory. The buoy is now undergoing a further trial off the Wolf Rock Lighthouse, and the reports as to its efficiency from masters of passing vessels are very encouraging.

The Submarine Signal Company had established in the United States a submarine bell suspended from an iron tripod resting on the bed of the sea, and connected by electric cable to a power station on the mainland. The efficiency of submarine bells having proved so satisfactory, the Corporation was induced to put down a bell on this system about a mile seaward of the North Stack fog signal station, in the direct route between Holyhead and Dublin, the necessary electricity being transmitted through a cable from the power producing plant at South Stack Lighthouse, where machinery was available in connection with an aerial fog signal. The work was successfully carried out by the Trinity House, and the bell, which was suspended from a tripod at a depth of 25 fathoms, was brought into operation on the 21st October last, since which date it has been in action during fog, and is believed to have given every satisfaction to the vessels of the London and North-Western Railway Company, the City of Dublin Steam Packet Company, and others. It has been favourably reported on by the Captains of some of the vessels of the White Star Fleet, and on one occasion was heard at a distance of eleven miles. The Trinity House has now arranged to place a similar bell two miles S. by W. ½ W. from the Lizard, the tripod for which will rest on the bed of the sea at a depth of about 35 fathoms, the electric cable being connected to the power producing plant at the electric lighthouse station thereat, and the Corporation intend to extend the system of submarine signalling on light vessels and buoys during next year.

It may be mentioned that three of the Trinity House steam vessels are equipped with the necessary receiving apparatus for locating the position of submarine bells.

SIDELIGHTS ON WORKMEN'S COMPENSATION.

SOME interesting statistics and opinions with regard to workmen's compensation are to be found in the report of Dr. Collie, who is medical examiner to the London County Council. His duties include the examination of men entering the Council's service, the investigation of sickness and cases of accident among the servants of the Council, and medico-legal cases in which claims are made against the Council. Dr. Collie has made discoveries of importance with regard to the eyesight of tramway drivers. In 1904, when he began to examine the eyesight of drivers in the employment of the Council, he found that of 73 examined, 13 were wholly unfit for the service. Two of them could only read at one-third of the normal range, while one man who had actually been driving could not read at 20ft. what he ought to have been able to read at 200ft. If these are the results of an examination of the Council's drivers, what would be the result of an examination of the eyesight of the countless persons who drive motors through the streets of London? Dr. Collie's investigations would appear to justify a change in the law by which persons applying for licences as drivers of motor cars could be made to submit themselves for examination by an eye specialist. Coming to the statistics of workmen's compensation, there is a very striking contrast between the results of claims made against the County Council on the one hand and the statistics for the whole country. In 1908, out of 328,957 cases throughout the country, no fewer than 326,454, or 99.3 per cent., were settled out of court, and of the remaining 2503 which came into court, 82 per cent. went in favour of the applicant. With the County Council, however, things are very different. Acting—as we may assume—under the able guidance of Dr. Collie, they took nearly 25 per cent. of their cases into court, and settled only 75 per cent. outside. In court the Council won over 81 per cent., and lost only 19 per cent.! The inference may be drawn that employers generally and insurance companies are willing to pay up rather than be troubled with litigation. That Dr. Collie is an adept at catching the malingerer is also clear from his report. In one case a man complained of obscure pains and malingered for thirteen months without any objective symptoms. He was six times reported fit for duty, and every time he obtained a certificate of unfitness. At last, having been under observation for nine weeks, he was ordered to be dismissed, and to forfeit all superannuation benefit if he did not return to work at once.

THE ELGAR SCHOLARSHIP.—The Elgar Scholarship in Naval Architecture, of the annual value of £50, and subject to certain conditions, tenable for three years, will be offered for competition by the Council of the Institution of Naval Architects. Candidates must at the time of the examination be students of the Institution, and not less than 18 or more than 21 years of age on 1st March, 1910, and must at that date have been continuously employed for two years upon naval architecture or marine engineering. Further particulars and forms of entry and conditions regulating the admission of students may be obtained from the Secretary, Institution of Naval Architects, 5, Adelphi-terrace, London, W.C. Applications must be sent in by February 1st, 1910.

THE FIRST DREADNOUGHT.—Our contemporary, the *Scientific American*, has just produced an interesting claim to the effect that America produced the first Dreadnought. The claim is that the first "all big gun ship" was the Roanoke, an old frigate which survived the attacks of the Merrimac in Hampton Roads during the Civil War. After the famous fight between the Monitor and the Merrimac, the Roanoke was armoured and fitted with three turrets in the centre line. Unlike the Monitor, so plentifully built at that date (1863), the Roanoke had a high freeboard, and, from the illustrations published by the *Scientific American*, there certainly appears sufficient resemblance to the Dreadnought to substantiate the claim. It is an interesting example of the proverb that "There is nothing new under the sun."

VIENNA SCAVENGING SYSTEM.—The Municipality of Vienna are preparing to lay out over £400,000 on a new scavenging system for the removal and final disposition of house refuse, ashes, &c. It is proposed to adopt the Koprophor method of covered metal receptacles to be placed in the court-yard of every house. These will be emptied into specially constructed ash carts, so designed as to avoid the dissemination of dust in the air. Round metal boxes will be used instead of square, as being more easily cleaned out. Some 60,000 will be required, besides 140 wagons. The refuse will be consumed in three large destructors, to be built in different parts of the city. One will be erected close to the municipal electrical plant, for which it will furnish heat and steam. Every householder will have to contribute a special tax of 12s. 6d. a year towards the cost of removal of the refuse. As the city budget for last year shows a considerable deficit, the ratepayers can hardly welcome this contemplated new outlay.

COMPOUND STRESS EXPERIMENTS.[1]

By Mr. C. A. M. SMITH, B.Sc., Associate Member, Assistant Professor of the East London College (University of London).

(I.) *Theories of elastic failure.*—The object of this paper is to give certain experimental results which have been obtained upon solid steel bars subjected to compound or combined stress. An attempt is made to indicate briefly the methods used during the experiments. The practical results of such experiments are chiefly connected with the design of crankshafts and that matter is therefore discussed. The following systems of loading the specimen were adopted, and in each case the maximum stress on the material at elastic failure was noted: (1) Compression only; (2) torsion only; (3) combined compression and torsion; (4) tension only; (5) combined tension and torsion. The notation for such stresses, used throughout the paper, is, for compression $+ p$; for tension $- p$; for torsion q. There are four theories of elastic failure of materials:—

(1) *The maximum principal stress theory.*—This is known as the Rankine theory, and may be calculated by the formula

$$\frac{p}{2} + \sqrt{\frac{p^2}{4} + q^2} = C_1.$$

(2) *The maximum principal strain theory.*—This is known as St. Venant's theory and may be calculated by the formula

$$\frac{1}{E}\left\{\frac{p}{2} + \sqrt{\frac{p^2}{4} + q^2} - \frac{1}{m}\left(\frac{p}{2} - \sqrt{\frac{p^2}{4} + q^2}\right)\right\} = C_2.$$

(3) *The maximum shear stress theory.*—This has been called, for mild steel, Guest's law, and may be calculated by the formula

$$\sqrt{\frac{p^2}{4} + q^2} = C_3.$$

(4) *The internal friction theory.*—This is known as Navier's theory, and may be calculated from a formula

$$\sqrt{\frac{p^2}{4} + q^2}\ \mathrm{Sec}\ \phi - \frac{p}{2}\tan\phi = C_4.$$

The first two formulæ are to be found in all text-books on the strength of materials. The results of the author's experiments show that, for mild steel, elastic failure takes place by reason of the maximum shear stress, under all conditions of loading.

(II.) *Previous experiments.*—In order that the object of the investigations may be fully understood, it is thought advisable to mention a few facts of especial interest to members of this Institution. In the year 1900 Mr. J. J. Guest[2] published the results of some experiments made upon tubes subjected to tension, torsion, and internal fluid pressure. Nine steel tubes were used. These experiments did not, for some time, receive very much recognition, probably for two reasons: (1) a great deal of space was occupied, in the paper embodying the results, with a description of the instruments used; (2) engineers are sceptical about results, as to elastic strength of materials, obtained upon tubes. Mr. Guest's experiments and the practical results of the deductions to be made from them have been discussed by the author.

Reference will be made to probable sources of error in these experiments which may have considerably affected the results. Mr. Guest showed that the shear stress at elastic failure was more constant than the principal stress or the principal strain when the material was loaded in tension and torsion. In 1906 Mr. Walter Scoble attempted to solve the problem by conducting tests upon material subjected to combined bending and twisting.[3] These experiments seemed to confirm the above. Although a system of loading by combined bending and torsion was adopted, there was no evidence to show that the material did not fail by reason of a shear stress due to a combined stress of tension and torsion. A difficulty was experienced in locating elastic breakdown. For the tests published the average variation from the mean is, for the shear stress theory, 3.72 per cent., and for the maximum principal stress theory, 18.3 per cent. In America Professor E. L. Hancock[4] attacked the problem, but he obtained contradictory results. The author has dealt with the work of Mr. Scoble and Professor Hancock elsewhere. The experiments of Professor Hancock appear to refute the shear stress theory, but the variations in the results are so great that it cannot be said with certainty that they confirm or reject any of the theories of elastic failure.

It may be mentioned that Mr. Laurence B. Turner has compared the elastic failure of steel tubes subjected to simple tension and simple torsion. He says: "Nineteen comparisons in simple pull and simple torque having been made, it is found that the difference between the shears is generally small." The author has published results on copper tubes, solid steel specimens, hollow machined steel specimens,[5] and various non-ferrous materials.[6]

All of these experiments have been made by independent investigators, and have caused considerable discussion in the technical journals. From the very nature of the problem it was inevitable that any new formula recommended would need experimental results for its support before it would be accepted. Such experimental work involves new apparatus, and requires the consideration of many details which at first appear extraneous to the work, and are in themselves in the nature of preliminary researches or experiments. More than 300 tests have been made at the East London College; most of them included about seventy readings of extensions. It is impossible to include a full account of such work in any one paper, but throughout the author has endeavoured to give references to enable those interested to investigate such details.

After a careful study of the "Proceedings" of the technical societies, it was evident that the engineers demanded further evidence concerning the behaviour of mild steel under combined stress. In June, 1903, Mr. William H. Maw, in the "James Forrest" lecture, commented upon the need of further research work on the subject.[7] In 1906 Mr. C. E. Stromeyer said that "he trusted that the question of compound stresses would, if possible, be taken up by the Institution.[8]

(III.) *Solid steel bars used.*—This was the problem which offered itself for solution when the research work was commenced some years ago by the author. Mr. Guest's experiments, while fully appreciated by a few people, were either not very well known or not sufficiently convincing to influence the general body of engineers. Moreover, there was only evidence that the law held for a combination of stresses due to tension and torsion. Lord Kelvin had suggested that a compression load, in combination with a torque on mild steel, would raise the yield point of the material. If this were proved to be the case the shear-stress theory of elastic failure would seem to break down. It was, therefore, necessary to make experiments upon steel, not only for a combination of tension and torsion, but especially for a combination of compression and torsion.

Preliminary experiments caused the author to adopt solid steel specimens. He found that tubes were unsatisfactory for the following reasons:—

(1) It is only possible to apply a tension load by grips which cause distortion, or by means of solder which necessitates heating the ends of the tubes.

(2) The material is not isotropic. Annealing reduces this evil, but it seems to be doubtful whether it entirely removes it.[9]

(3) Difficulty of making accurate measurement of areas subjected to the loads.

(4) With thin tubes strain-measuring instruments are not easily secured to the specimen.

(5) When loaded in compression the tubes may fail by reason of secondary flexure.

(6) Engineers do not seem to have confidence in the elastic breakdown tests made upon tubes.

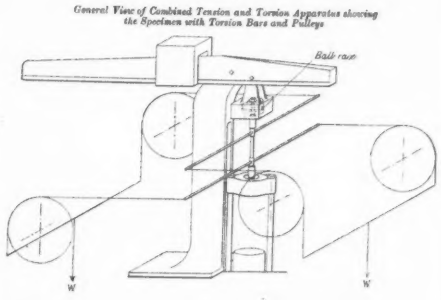
The great advantage to be gained by using tubular specimens is that the stress distribution, during a torsion test, is the same over all of the material.

Preliminary experiments were made upon both solid and tubular mild steel specimens and it was then decided to use solid bars.

(IV.) *Tension and compression tests.*—In most of the author's experiments, quoted in this paper, a specimen of 1in. diameter was used. The length between the shoulders was 4¾in. The reason why similar specimens were used for torsion, tension, compression and combined stress tests was that it was desired to make them interchangeable for elastic range tests.[10] The ratio of the length to the diameter was sufficient to ensure that, unless the loading during a compression test was placed with considerable eccentricity, the yield point in compression would be reached before the specimen failed as a strut. If the loading is directly through the axis of the specimen it is safe to make this ratio twenty for a mild steel specimen.

FIG. 1.

General View of Combined Tension and Torsion Apparatus showing the Specimen with Torsion Bars and Pulleys

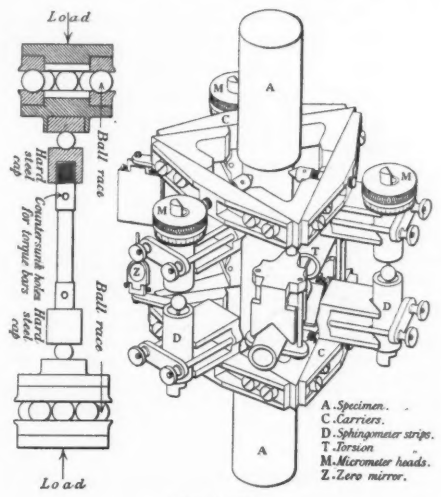


Previous experiments with various grips were made, and as a result the specimens were turned with screwed ends, gas threads being used. The general shape of the specimen and the arrangement of the apparatus is indicated in Figs. 1 and 2. The screwed ends were carefully fitted to the tension grips and the compression caps. The centre 4½in. of the specimen was turned parallel to 1 in 2000. Torque bars were fastened by set screws, which fitted directly on to the specimen at the top and bottom, as shown in Fig. 1.

A 50-ton Wicksteed testing machine was used for the application of tension and compression loads. Ball bearings were fitted so that the specimen was free to revolve when tested in torsion.

The torque bars were flexibly coupled together and moved simultaneously, the friction of the ball bearings being thus eliminated before a reading was taken.

For measuring strains produced by tension or compression stresses the sphingometer was used. An earlier form of the instrument is possibly known to members of this Institution,[11] and the improved type has been described in detail recently by the author.[12] It was necessary to make a number of preliminary experiments upon columns in order to determine the most suitable proportions for the specimens used in the compression tests. It was anticipated that there would be difficulty in securing axial loading for the compression tests, and for that reason some new method of measuring strains was considered desirable. Since the accuracy of the experiments recorded depend upon the instrument a brief description is given, and an isometric projection is shown in Fig. 3.



Figs. 2 and 3

Two carriers are fastened to the specimen, each by three set screws. The distance apart of the set screws is the gauge length, and can be accurately measured. Three strain-recorders, in planes of 120 deg., indicate the "stretch" of the specimen in these three planes. Each strain-recorder is calibrated separately and at the commencement of every test. The sensitiveness of the three strips may be varied as rapidly as the springs of a steam engine indicator. Appendices II. and III. give proofs that the mean extension of the three strips is equal to the extension of the specimen as a whole, and that, given the readings from the three strips, the maximum stress as well as the mean stress on the specimen can be determined. The whole object of the sphingometer is to enable the maximum stress at elastic breakdown upon a specimen in tension or torsion to be calculated.

(V.) *Torsion tests.*—Fig. 1 gives a general idea of how the torque was applied to the specimen. The torque arms were actually secured by means of set screws let into countersunk holes in the specimen. From the end of each torque bar a cord was carried over a bicycle wheel and fastened to a knife-edge upon which rested a hollow bar. A tray was hung by a knife edge on the centre of this bar, and weights marked W were placed in the tray in order to apply a torque.

From the arrangement of the pulleys shown in the sketch it will be seen that every effort has been made to eliminate bending during the application of the torque. Owing to the longer distance between the points of support of the specimen, the stress caused by bending—due to bad application of the torsion load—is greater during a tension than during a compression test.

A probable source of error in Mr. Guest's experiments may now be explained. He used long torque bars at the top end of the specimen, and two shorter bars at the bottom end. These two lower bars were brought against stops. The advantage of this arrangement was that it was only necessary to use one tray and one set of weights; but it is doubtful whether the two shorter bars were stopped in a satisfactory fashion. If only one lever had been resting on the atop, considerable bending resulted. It is almost certain that unequal springing took place, which caused unequal forces at the end of the torque bars. This in turn caused bending of the specimen, and it is probable that the stress caused by such bending was 4 or 5 per cent. of the total stress. An example, selected from the author's data, may make this point clearer. During the torsion tests the weight in the scale-pan at elastic failure was about 100 lb. Let us assume that the difference between the forces at the end of the torque arms was 30 lb. Then, since the distance between the spherical seats of the tension grips was 21in. and the torque bars were secured 8in. from each spherical seat, we should have had a bending moment on the specimen caused by the unbalanced force of 30 lb. This force would produce a stress of approximately 1500 lb. per square inch on the specimens used. The stress on such a specimen, at yield point, obtained by a pure torque was 18,000 lb. per square inch. Thus an error of 10 per cent. could be easily caused by using stops. This method of loading was therefore abandoned by the author, and the arrangement shown in Fig. 1 was adopted.

Incidentally, it may be mentioned that the treatment of the tubes used by Guest, between the experiments made upon the same tube, may have affected their elastic properties, especially if there was any interval of rest.

In the author's experiments the torsional strain was measured by means of a sphingometer strip shown at T, Fig. 3. This was placed at right angles to the strips used in the tension and compression tests. The strip was calibrated for each test. A full description of this additional fitting, together with a proof of the accuracy of the method employed for calibration, has been published.[13]

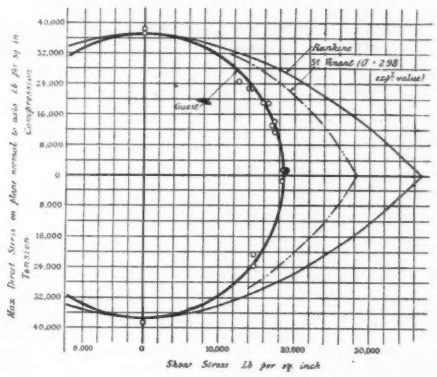
By the use of ball bearings in the testing machine and the pulleys the effect of friction was reduced to a minimum and was negligible.

The sphingometer strips rendered it a simple matter to record any strain however small.

(VI.) *The yield point.*—In the experiments recorded (8 S specimens) the elastic limit and the yield point coincided. In the case of perfectly homogeneous specimens loaded in tension and compression in such a manner that the load passes through the axis of the specimen—and consequently there is no bending—the yield point is marked by a rapid increase of stretch which takes place for a small addition of load. The author's experiments showed that the load never is acting exactly through the axis of the specimen. Some of the material used (S S specimens) was remarkably homogeneous, but the load was always slightly non-axial. In such a case there will be an apparent "elastic limit effect" if an extensometer is used which merely measures a mean extension of the specimen. With non-axial loading, and a homogeneous material, the yield point is reached at one portion of the specimen before the whole of it yields. With an extensometer which gives the distribution of stress, there will be an apparent rapid change in the eccentricity of loading directly any portion reaches the yield point. Then will follow the "elastic limit effect" (during which the mean extension of the specimen is slowly increasing for equal increments of load) due to eccentric loading, and then will come the total yield shown by a great increase in strain. What has been recorded in these experiments is the maximum stress on the specimen when the first portion of it reaches the yield point.

FIG. 4. *Experimental results showing the relation of Direct to Shear Stress at failure.*

The shear stress is here plotted to twice the scale employed for the direct stress, the Guest ellipse thus becoming a circle.



Until the load is reached at which this first portion yields there seems to be no "time effect," but at this point that phenomenon becomes most marked.

If the material is not homogeneous the problem is more complex, and need not now be discussed: (1) because the material used, especially that of the S S specimens, was almost homogeneous; (2) and further, such material cannot be expected to give much evidence concerning the theories of elastic failure, since the specimens vary in elastic properties.[14]

Every specimen tested, except those of mild steel, had an elastic limit as distinct from a yield point. This shows that the material was not homogeneous. It would appear that mild steel as now manufactured is very much more homogeneous than other materials used by the engineer. When several specimens were cut off the S S mild steel bar they seemed to be almost exactly similar with regard to elastic properties. The specimens of special steels and non-ferrous materials tested did not possess this property, so essential for the experiments discussed in this paper.

During the torsion tests the loads were added by small increments. In Appendix I. the full record of one of these tests is given. An examination of figures under the columns "Torque load" and "Deflection of torsion strip" will show that the readings were extremely regular until a certain critical load was reached. At that load the beam of light on the scale which

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[1] The Institution of Mechanical Engineers.
[2] *Philosophical Magazine*, 1900.
[3] *Philosophical Magazine*, Vol. xii., page 535.
[4] *Philosophical Magazine*, Vol. xii., page 418.
[5] *Journal*, Junior Institution of Engineers, July, 1909.
[6] "Elastic Breakdown of Non-ferrous Metals." Paper read before the Institute of Metals, October, 1909.
[7] "Some Unsolved Problems of Engineering." "Proceedings," Institution of Civil Engineers, Vol. cliv.
[8] "Proceedings," Institution of Mechanical Engineers, 1906, page 38.
[9] In this connection it is worth noting that the matter is discussed in *Science Abstracts*, No. 1225 (1908) and No. 965 (1908). Experiments were made to determine the effect of extension, flexure, and torsional strain on iron wires. In the latter abstract we read "metals are only rendered isotropic to a very approximate extent by annealing."
[10] *Journal*, Junior Institution of Engineers, pages 562, 573
[11] "A Method of Detecting the Bending of Columns," "Proceedings," Institution of Mechanical Engineers, 1908, Part III., page 699.
[12] *Journal*, Institute of Metals, 1909.
[13] "The Torsion Sphingometer." Institute of Metals, 1909, Appendix II.
[14] This point is especially revealed in the tests recorded in the author's paper to the Institute of Metals, previously mentioned. The elastic properties of certain specimens of arsenic copper, high-conductivity copper, rolled aluminium, and brass tubes are discussed at length in that paper.

recorded the strain began to travel rapidly, and the load was at once removed.

One advantage claimed for tubes in compound stress experiments is that the yield point of the material during a torsion test is well defined. In the torsion tests on these solid specimens of S S steel there was no difficulty in noting the yield point. It is believed that the reasons are: (1) the arrangement to obtain a pure torque and no bending; (2) the material was remarkably homogeneous. It should be mentioned that the torsional strain instrument was so sensitive that the first indication of yielding could be detected, and an interval was allowed so that it was certain that the material would not strain further at each increment of the load. Within the torsional yield point there was no "time effect" upon this material, although that phenomenon had been observed to take place with other specimens, notably aluminium.[15]

(VII.) *The results with the mild steel specimens.*—The accompanying Table I. and the illustration—Fig. 4—show the results obtained with the S S steel. The percentage chemical composition was:—Carbon, 0.20; silicon, 0.08; sulphur, 0.14; phosphorus, 0.032; manganese, 0.50. Table II. gives the results of tests on H T steel, which are shown graphically on Fig. 5. This material was not so homogeneous as the S S mild steel, and the results are therefore not so regular.

This was not discovered till the end of the test. Great eccentricity of the load was thus caused, and the special seats did not take this up. The ratio of maximum to mean was nearly 3 to 1.

Tests on other steels.—A large number of tests have been made upon special steels, and the author regrets to be compelled to state that the results were extremely unsatisfactory. He refrains from a complete analysis of these tests, although many instructive points have been learnt about the properties of the materials tested. The two great troubles experienced were: (1) Different specimens from the same bar tested in simple torsion or simple direct stress did not give repeated results; (2) the elastic breakdown was "veiled," and the "time effect" so great that no complete result concerning combined stress can be accepted which depends upon such variable material. A few examples will make this clear.

Self-hard steel.—The results of tests made upon this material contrasted sharply with those made upon a good quality mild steel. It was found that, with each of the specimens tested, the strain and stress were not proportional at moderate values of the stress, yet considerable increase in the applied load produced only a sensible increase in the strain. The stress strain diagram for the material gradually bent over. Specimen self-hard No. 1 was tested in pure torsion, and the elastic breakdown occurred when

TABLE I.—*The Results S S Steel (Tests made during June* 1908 *and February and March*, 1909)

Specimen and test.	Diameter.	Direct load tons + p compression − p tension.	Torsion load.	Ratio* max. stress mean stress in horizontal section.	p.	q.	Max. principal stress $\frac{p}{2}+\sqrt{\frac{p^2}{4}+q^2}$.	Max. shear stress $\sqrt{\frac{p^2}{4}+q^2}$.	Max. principal strain × 10^3.	Torsion slip approx.
			lb.							p.c.
SS 1.*a*	1.003	0.5	96	1*	1,420	18,500	19,250	18,540	0.813	1½
SS II.*a*	1.001₇	0.5	93	1	1,420	18,960	19,710	19.000	0.833	2
SS II *b*	1.001₇	0.5	96	1	1,420	18 580	19,330	18,620	0.817	1
SS II.*c*	1.001₇	8.0	74	1†	22,800	14,310	29 700	18,300	1.052	6
SS III.*a*	1.000	8.0	72	1	22,800	13,920	29,400	18.000	1.038	3
SS I.*c*	1.003	0.5	96	1	1,420	18,500	19,250	18,540	0.813	20
SS I.*d*	1.003	0.5	94	1	1,420	18,110	18,860	18,150	0.796	2
SS I*e*	1.003	5.0	90	1	14,200	17,350	25,850	18,750	0.970	20
SS IV.*a*	1.002	0.5	96	1	1,420	18,540	19 230	18,580	0.816	2
SS IV.*b*	1.002	2.0	90	1.975	11,200	17,390	23,860	18,260	0.916	2½
SS IV.*c*	1.002	4.0	83	1.15	13,080	16,990	24.760	18,220	0.935	2½
SS IV.*d*	1.002	6.0	82	1.125	19,300	15,850	28,100	18,500	1.017	2½
SS IV.*e*	1.002	8.0	65	1.089	24,750	12,540	30,030	17,650	1.046	3
SS I.*f*	1.003	0.5	95	1	1,420	18,300	19,050	18,340	0.805	9
SS V.*a*	1.002₅	10.2	0	—	Bent, load removed before yield.					
SS V.*b*	1.002₅	0.4	88	1	1,140	18,910	19,450	18,940	0.828	2
SS V.*c*	1.002₅	3.0	94	1.134	9,650	18 110	23,545	18,7·0	0.917	2
SS V.*d*	1.0₂5₅	6.0	86	1.111	18,930	16,590	28,550	19,080	1.040	—
SS VII.*a*	1.002	−0.5	95	1	−1,420	18,350	19,080	18,390	0.817	2
SS VII.*b*	1.002	Between 10 and 10.5 tons bent badly and failed.								
SS VI.*a*	1.003	Taken to 9.7—no yield in tension—grips slipped.								
SS VI.*b*	1.003	9.5			"	"	"	"		
SS VI *c*	1.003	−7.0	76	1.192	−23,770	14,690	30,790	18,900	1.088	6
SS VIII.*a*	1.002	−7.0	76	1.036	−20 570	14,660	28,210	17,940	1.010	3
SP 4A	1.026	−12.7	0	1.1₀9	−38,800	0	38,800	19,400	1.284	—
SP 4B	1.026	+12.5	0	1.0₆9	+37,250	0	37,250	18 640	1.233	—
MP 4	0.9₀9	12.7	0	1.065	−38,600	0	38,600	19,300	1.278	—
MP 6	1.026	+13.5	0	1.0₆0	+38,450	0	38,450	19,220	1.273	—

Torsion slip is given as a percentage of total elastic strain.
p = Maximum direct stress on horizontal plane. q = Maximum shear stress on horizontal plane.
* When given as unity exact value not known.
† In these early tests the stress distribution was not calculated, but a fair average value is taken now, in which case the stress becomes 18,900 and 18,700. Average variation from mean of maximum shear stress is 1.62 per cent.

TABLE II.—*Results of H.T. Steel Tests made in July*, 1909.

Specimen.	Diameter.	Direct load. Compression + Tension −	Torsion.	Ratio $\frac{\text{maximum}}{\text{Mean direct strain.}}$	p.	q.	Maximum principal stress $\frac{p}{2}+\sqrt{\frac{p^2}{4}+q^2}$.	Maximum shear stress $\sqrt{\frac{p^2}{4}+q^2}$.
		Tons.						
H.T. 1*a*	0.750	0.2	41	1	10,000	18,500	19,000	18,500
H.T. 2*b*	0.750	3.0	34	1.394	21,200	15,300	25,900	18,600
H.T. 2*c*	0.750	4.0	31	1.017	21,200	14,000	24,600	17,500
H.T. 3*a*	0.750	3.0	28	1.276	19,400	12,600	32,000	15,900
H.T. 3*b*	0.750	5.2	—	1.221	32,200	—	32,200	16,100
H.T. 4*a*	0.750	5.2	—	1.270	33,500	—	33,500	16,700
H.T. 4*b*	0.750	0.2	38	1	1,000	17,100	17,600	17,100

In addition to the S S and H T tests, numerous other experiments have been made upon different specimens. Several of these have been published, but it is thought desirable to give here a complete synopsis of all the work done upon steel. The following table enables the results to be seen.

The usual notation has been used.

In Test A D 4*a*, Table III., one of the balls was out of the race.

TABLE III.—*Tests on Mild Steel Specimens.*

Specimen and test.	Ratio $\frac{\text{Maximum}}{\text{Mean}}$ longitudinal strain.	Maximum principal stress $\frac{p}{2}+\sqrt{\frac{p^2}{4}+q^2}$.	Maximum shear stress $\sqrt{\frac{p^2}{4}+q^2}$.
S.C. 3*a*	1.000	19 800	19 500
S.C. 3*b*	1.000	19,800	19,500
S.C. 3*c*	1.070	26,100	21,000
S.C. 3*d*	1.058	29,500	20,400
S.C. 3*e*	1.036	32,300	20 400
S.C. 3*f*	1.189	34,900	19 900
S.C. 3*g*	1.062	36,500	18,900
Average variation, from mean, of maximum shear stress on S.C. specimens = 2.16 per cent.			
S.B. 1*a*	1.000	24 900	23,700
S.B. 1*b*	1.000	24,900	23,700
S.B. 1*c*	1.114	47,600	25,800
Average variation, from mean, of maximum shear stress on S.B. specimens = 0.21 per cent.			
A.D. 1*a*	1.000	−20,170	19,450
A.D. 2*a*	1.000	−20,560	20,420
A.D. 2*b*	1.083	−31 810	21,100
A.D. 3*a*	1.083	−31 570	20,700
A.D. 3*b*	1.114	−35 620	17.8 0
*A.D. 4*a*	2.958	−38,180	19,190
A.D. 4*b*	1.000	−20,750	20,610
A.D. 5*a*	1.069	+·7,950	20,320
A.D. 5*b*	1.043	+30,140	19 710
A.D. 6*a*	1.029	+·6,370	20.500
A.D. 6*b*	1.008	+29,050	20,420
A.D. 7*a*	1.112	+32,300	21.300
A.D. 8*a*	1.100	+36,420	18,210
A.D. 10*a*	1.000	+20,560	20,420
A.D. 11*a*	1.000	−19,190	19 050
A.D. 11*b*	1.375	−26,210	20,320
Average variation, from mean, of maximum shear stress on A.D. specimens = 4.62 per cent.			

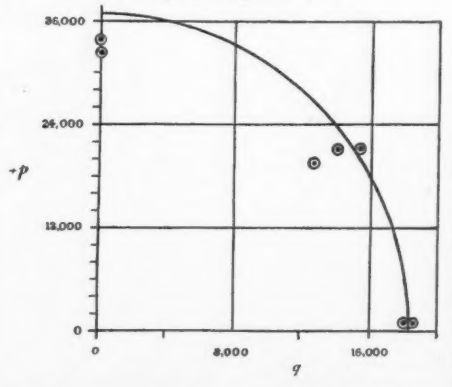
C = 11,660,000 lb. per square inch.
E = 29,250,000.
σ = 0.256.
* Note the stress distribution for this test.

[15] "The Elastic Properties of Non-ferrous Materials." Institute of Metals.

the maximum shear stress reached 16,120 lb. per square inch. Specimen self-hard No. 2 was tested in compression, and the maximum direct stress at elastic failure was 55,750 lb. per square inch. Specimen self-hard No. 3 was tested in tension; the direct stress at elastic failure was 55,650 lb. per square inch. Specimen self-hard No. 4 was tested in torsion, and the stress at elastic failure was 23,000 lb. per square inch. It would be unwise to build any formula upon material whose elastic properties vary so much.

Nickel steel.—This material, like the self-hard steel, was very indefinite with respect to the yield point. The values given are

FIG. 5.
Results of Tests on High Tensile Steel.



for elastic breakdown. Three tests seemed to suggest that the material obeyed Guest's law. The results are as follows:—N S 1 was tested in compression. Direct stress at elastic breakdown 45,100 lb. per square inch. N S 4 tested in tension. Direct stress at elastic breakdown 46,300 lb. per square inch. N S 3 tested in torsion. Maximum shear stress at elastic breakdown 23,000 lb. per square inch. N S 2 gave unsatisfactory results. It is hoped to investigate the elastic properties of this interesting material further. It may be said at once that the point of elastic breakdown can be considerably raised if the material is overstrained in the direction in which it is again tested. It is worth noting that the elastic breakdown of these nickel steel specimens took place at a stress about 25 per cent. in excess of that required to ensure elastic breakdown of the S S specimens. In Appendix III. curves are shown of a test on this N S material.

A series of experiments were made upon some specimens of mild steel of very low elastic limit. Two sets were supplied, but there was such variability in the material that the author hesitates to include them.

Several special steels have been tested, but on the whole insufficient material of any one type of such steels has been supplied to produce useful data. Very great difficulty was experienced in securing the instruments to some of the special steels; the specimens must have been most difficult to prepare. The stress at tensile elastic breakdown was 87,000 lb. per square inch on a forged material tested in tension.

The experiments lead to the following general conclusions:—

(1) The elastic failure of mild steel takes place when a definite shear stress is reached, and does not depend upon the value of the maximum principal stress nor the maximum principal strain.

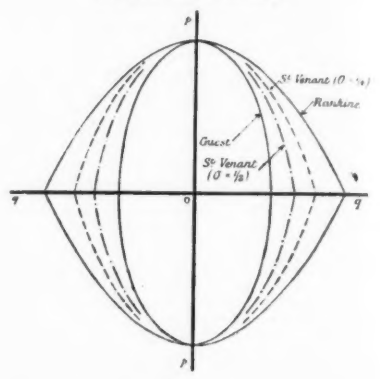
(2) The law, which Guest's work on tubes showed was approximately correct for mild steel tubes loaded in tension and torsion, is confirmed and applies also to the same material loaded in compression and torsion.

(3) The "elastic limit" effect noticeable during tension, torsion and compression tests on mild steel which has not been previously stressed, is probably due to a fault in applying the load, and to the method of measuring strains.

(4) The ratio of maximum to mean direct stress during elastic tests is greater than is usually assumed to be the case—see Appendix III.

FIG. 6. *Curves showing the relation of Direct to Shear Stress at failure according to the three theories of elastic failure.*

Both stresses to the same scale.



(5) The use of spherical seats does not ensure axial loading. This point is here mentioned, as it probably accounts for the discrepant results obtained by experimenters who have measured the elastic limit instead of yield point.

(6) The ratio of the working stresses for mild steel in tension and shear should be 2:1, and not, as is usually quoted in text-books, 5:4.

The curves—Figs. 6 and 7—show the relationship between torque and direct load at the yield point according to the three theories of elastic failure.

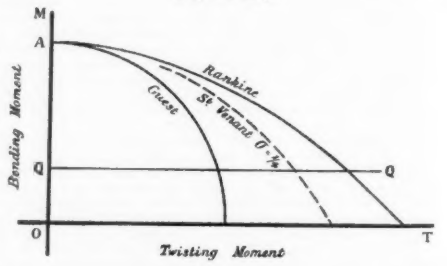
(VIII.) *The practical result.*—Although several cases of combined stress upon mild steel occur in engineering practice, the two chief cases are those of the boiler and the crank shaft. Both cases have been fully discussed by the author. It may be useful to record that if L be the equivalent bending moment, then, according to the four theories of elastic breakdown enumerated above, we have:—

(1) Rankine . . $L = \frac{1}{2}M + \frac{1}{2}\sqrt{M^2 + T^2}$.
(2) St. Venant . $L = \frac{3}{8}M + \frac{5}{8}\sqrt{M^2 + T^2}$.
(3) Guest . . . $L = \sqrt{M^2 + T^2}$.
(4) Navier[16] . $L = \frac{1}{1 + \sin\phi}(\sqrt{M^2 + T^2} + M \sin\phi)$.

The diagram, Fig. 7, shows the curves for the first three theories. The fourth theory is comparatively new, and has never

FIG. 7.—*Curve showing the relation of Bending-Moment and Twisting-Moment for a constant equivalent Bending-Moment.*

O Q = 0·30 A.



been advanced for the purpose of crank-shaft design; and it is omitted from the curves, as it would possibly confuse the diagram. It will be noticed that it reduces to Guest's law if tan $\phi = 0$—that is, if the coefficient of internal friction for steel is zero. All of the curves agree at A. But if any abscissa Q Q be drawn, it will be seen that, with an equivalent bending moment of value L, the permissible torques at that point shown on the diagram are, according to the three theories, Q = 0.954 L; Q = 1.390 L; Q = 1.673 L. The two latter are 46 per cent. and 76 per cent. higher than the first. In other words, crank shafts designed according to the principal stress or principal strain theory of elastic failure have had a false factor of safety.

There has been evident, since Guest published his experiments, some hesitation in accepting the practical conclusions which follow from the sheer stress theory of elastic failure. The author trusts that the discussion arising out of this paper and the results enumerated above will end the controversy which has taken place concerning the design of crank shafts and structures subjected to combined stress.

The author desires to thank the authorities of the East London College for the facilities extended to him for carrying out this work, also Sir William H. White, K.C.B., past president, Mr. H. F. Donaldson, C.B., member of Council, and Mr. W. J. Luke, for their personal interest in the experiments. He acknowledges the many opportunities afforded by Professor D. A. Low, and

[16] Recent experiments on mild steel specimens have given results approximating so closely to Guest's law that it may be stated that Navier's theory need not be considered for the design of crank shafts.

recognises the valuable assistance given by Mr. A. G. Warren and several students of the East London College; Mr. E. T. Cook, the college instrument maker; Messrs. Hadfield's Steel Works, the locomotive superintendent of the South-Eastern Railway, the Hoffman Ball Bearing Company, and other firms, for supplying material.

APPENDIX I.

A Combined Stress Test fully worked out.

Specimen S S V, test c.—Length of specimen between gauge points = 3.903in. Diameter, 1.0025in. Length of torque bars = 76.4in. Distance of sphingometer strips from axis of specimen = 2.58in.

Calculations for tension or compression test.—The following readings and calculations were made:—

	Strip No. 1.	Strip No. 2.	Strip No. 3.
Scale readings, compression load 0.5 ton	238	281	332
Scale readings, compression load 3 tons	130	234	134
Calibration equivalent of scale divisions in inches	0.00000776	0.00000917	0.00000752
Extension of strips in inches for load of 2.5 tons	0.000838	0.000431	0.001489
Surface extension in inches	0.000903	0.000824	0.001130

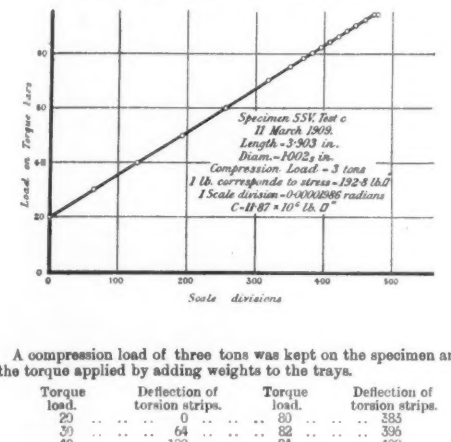
From the above the mean extension = 0.000919in., whence $E = 30.2 \times 10^6$ lb. per square inch.

The maximum surface extension (calculated as in Appendix III.) = 0.001041in., whence ratio $\frac{\text{maximum stress}}{\text{mean stress}}$ on surface perpendicular to axis = $\frac{1041}{919} = 1.134$.

Torsion test.—Calibration of torsion strip gave 1 division = 0.00001986 radians.

FIG. 8.

Curve showing the relation of Torsional Stress to Strain.


Specimen SSV. Test c
11 March 1909.
Length = 3·903 in.
Diam. = 1·002₅ in.
Compression. Load = 3 tons
1 lb. corresponds to stress = 192·8 lb/□"
1 Scale division = 0·00001986 radians
C = 11·87 × 10⁶ lb. /□"
Load on Torque Bars
Scale divisions

A compression load of three tons was kept on the specimen and the torque applied by adding weights to the trays.

Torque load.	Deflection of torsion strips.	Torque load.	Deflection of torsion strips.
20	0	80	385
30	64	82	396
40	128	84	409
50	193	86	422
60	256	88	434
70	319	90	447
75	351	92	461
78	370	94	474*

* Slipped rapidly to 480 and load immediately removed.

Fig. 8 shows the curve for this test, on which the yield point is evident.

It will be seen that an increase of 70lb. caused a deflection of 447 divisions.

$$\text{Whence strain} = \frac{0.501 \times 447 \times 0.00001986}{3.903}$$

$$\text{Torque} = \frac{70 \times 76.4}{2} = \frac{\pi}{16} f d^3$$

whence $f = 13{,}510$ lb. per square inch.

$C = 11.87 \times 10^6$ lb. per square inch.

Now since $(1 + \sigma)\, 2\, C = E \therefore \sigma = 0.298$.

Stresses at yield point.

$$p = \frac{3 \times 2240 \times 4}{\pi \times 11005} \times 1.134 = 9650 \text{ lb. per square inch.}$$

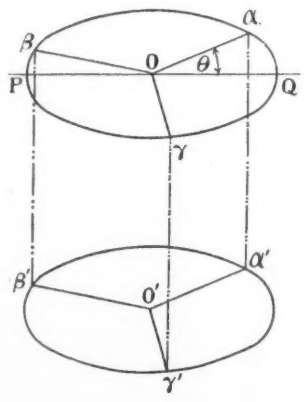
$q = 18{,}110$ lb. per square inch.

$\therefore$ Maximum shear stress = 18,720.

Maximum principal stress = 23,540.

Maximum principal strain = 0.917×10^{-3}

FIG. 9.



APPENDIX II.

Proof that the mean extension of the three strips of the sphingometer is equal to extension of the specimen as a whole. Further, that the variations from the mean of the three readings are the variations of the corresponding generating lines on the specimen, magnified in the ratio of the diameter of the cylinder, passing through the strips, to the diameter of the specimen. Also to find the amount of bending.

From the extension of the three sphingometer strips equally spaced round and from the axis of the specimen and parallel to it, we obtain three measurements.

If there were no bending on the specimen and the material were perfectly homogeneous, these extensions would all be equal. That the variations are due to a bending moment (probably because the load is placed eccentrically) is evidenced by the fact that the mean of all the readings, up to the elastic limit of the material, obeys a linear law.

The sphingometer carriers and strips are shown diagrammatically in Fig. 9 to which the following symbols belong:—

Let $\alpha\ \beta\ \gamma$, $\alpha'\ \beta'\ \gamma'$ represent the fixed ends of the sphingometer strips. Let O and O′ be the centres of the triangles $\alpha\ \beta\ \gamma$ and $\alpha'\ \beta'\ \gamma'$. Then the displacement of $\alpha\ \beta\ \gamma$ with respect to $\alpha'\ \beta'\ \gamma'$ may be resolved into a motion of O to or from O′ and a rotation of the plane $\alpha\ \beta\ \gamma$ about some axis such as P Q.

As all motions are relative, there is no need to consider the points $\alpha'\ \beta'\ \gamma'$, and for the purpose of investigation these may be considered fixed. The points $\alpha\ \beta\ \gamma$ move by a combination of two motions. There is the increase (positive or negative) of O O′—the extension—which is part of the increase of length of strip, and there is also the change in length due to an alteration in the inclination of the planes $\alpha\ \beta\ \gamma$, $\alpha'\ \beta'\ \gamma'$ to each other. The line PQ in the plane $\alpha\ \beta\ \gamma$ is called the axis of bending, and the angle between the planes divided by O O′—the radian bend per unit length—is the amount of bending.

The mean extension.—

Let the angle α OQ be θ,

then the angle β OQ is $\left(\theta + \frac{2\pi}{3}\right)$,

and the angle γ OQ is $\left(\theta + \frac{4\pi}{3}\right)$.

Let the angle between the two planes, which were originally parallel, be ϕ after straining. Let x be the true extension of the specimen. Then we have, if

A = extension of strip

$r = \text{O}\alpha = \text{O}\beta = \text{O}\gamma$,

the angle ϕ is measured in radians, and is considered small.

We may take $A = x + \phi\ r \sin\theta$.

Similarly for the other strips we have

$$B = x + \phi\ r \sin\left(\theta + \frac{2\pi}{3}\right)$$

and

$$C = x + \phi\ r \sin\left(\theta + \frac{4\pi}{3}\right).$$

Then the arithmetic mean of the reading of the strips is

$$x + \frac{\phi r}{3}\left(\sin\theta + \sin\left(\theta + \frac{2\pi}{3}\right) + \sin\left(\theta + \frac{4\pi}{3}\right)\right) =$$

$$= x + \frac{\phi r}{3}\left\{\sin\left(\theta + \frac{2\pi}{3}\right)\right\}\left\{1 + 2\cos\frac{2\pi}{3}\right\}.$$

But

$$2\cos\frac{2\pi}{3} = -1.$$

Therefore the mean reading of the strips is x—that is to say, the extension of the axis of the specimen is obtained by taking the mean of the three strip readings.

FIG. 10.—*Specimen NS 4, Test a.* (23 Nov. 1909.)
Length = 2·05 inches. Diam. = 0·7500 inch. $E = 27{\cdot}1 \times 10^6$ (for 2 tons).

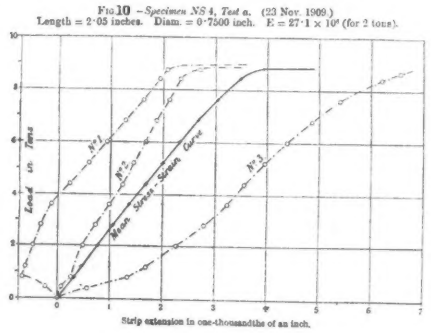
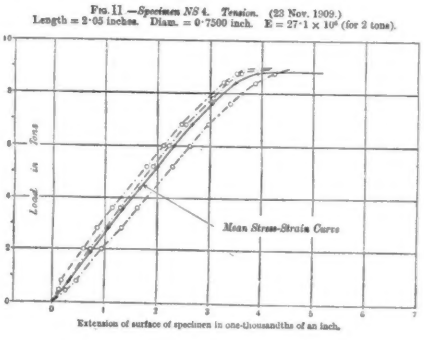


FIG. 11.—*Specimen NS 4. Tension.* (23 Nov. 1909.)
Length = 2·05 inches. Diam. = 0·7500 inch. $E = 27{\cdot}1 \times 10^6$ (for 2 tons).



Change in length due to bending.—

Let $A' = A - x$

$B' = B - x$

$C' = C - x$

Then we have

$$A' = \phi\ r \sin\theta \quad \ldots\ldots\ldots \text{(ii)}$$

$$B' = \phi\ r \sin\left(\theta + \frac{2\pi}{3}\right) \ldots\ldots \text{(iii)}$$

$$C' = \phi\ r \sin\left(\theta + \frac{4\pi}{3}\right) \ldots\ldots \text{(iv)}.$$

From these equations $\phi\ r\ \theta$ can be found.

It is only necessary to have two equations, since we know that $A' + B' + C' = 0$. It is, however, more convenient to work with the three, and select in practice those expressions which are least dependent on errors of measurement.

Dividing (iii) and (iv) by (ii) we have

$$\text{Cot}\,\theta = \frac{2}{\sqrt{3}}\left(\frac{B'}{A'} + \frac{1}{2}\right) = -\frac{2}{\sqrt{3}}\left(\frac{C'}{A'} + \frac{1}{2}\right).$$

It will in practice be found most accurate to take A as the largest numerically. The value for two expressions of cot θ may be taken; if not quite equal, select a mean value, and look up the angle in the tables.

Having found θ, we have

$$\phi = \frac{A'}{r \sin\theta} = \frac{B'}{r \sin\left(\theta + \frac{2\pi}{3}\right)} = \frac{C'}{r \sin\left(\theta + \frac{4\pi}{3}\right)}.$$

The amount of bending is $= \frac{\phi}{l}$.

APPENDIX III.

A method of determining the maximum stress when given the displacements of three points spaced equally around the specimen.

In any stressed specimen the mean stress can be easily calculated. It remains to find the ratio of the maximum to the mean stress in order to determine the maximum stress to which the specimen is subjected.

Referring to Fig. 9, let A, B and C be the stresses at the points on the specimen corresponding to α β and γ. Let S be the maximum stress on the specimen.

Then, writing stresses for strains in the equations (ii), (iii), and (iv), Appendix II., we obtain the corresponding relations, namely:—

$$A = \frac{A + B + C}{3} + \left(S - \frac{A + B + C}{3}\right) \sin\theta \quad \ldots\ldots \text{(i)}$$

$$B = \frac{A + B + C}{3} + \left(S - \frac{A + B + C}{3}\right) \sin(\theta + 120\text{ deg.}) \quad \text{(ii)}$$

$$C = \frac{A + B + C}{3} + \left(S - \frac{A + B + C}{3}\right) \sin(\theta + 240\text{ deg.}) \quad \text{(iii)}$$

Then expanding and eliminating between the first two expressions above we have:—

$$\left(S - \frac{A + B + C}{3}\right)^2 = \frac{4}{3}\left[\left(A - \frac{A + B + C}{3}\right)^2 + \left(A - \frac{A + B + C}{3}\right)\left(B - \frac{A + B + C}{3}\right) + \left(B - \frac{A + B + C}{3}\right)^2\right].$$

The application of this method is first of all shown with hypothetical figures, which are simpler than those actually obtained in practice.

Suppose that the distance of the centre of the strip from the centre of the specimen is four times the radius of the specimen. Suppose the sphingometer readings to be 6, 8 and 10. Then the mean extension of the strips and of the specimen will be 8, and the surface strains will be the mean, together with the differences from the mean of the sphingometer readings reduced in the ratio of 4 to 1, that is,

$$8 + \left(\frac{-2}{4}\right);\ 8 + \frac{0}{4};\ 8 + \frac{2}{4} = 7\tfrac{1}{2};\ 8 \text{ and } 8\tfrac{1}{2}.$$

Then we have from the above if S is the maximum strain

$$(S - 8)^2 = \frac{4}{3}\left[(7\tfrac{1}{2} - 8)^2 + (7\tfrac{1}{2} - 8)(8 - 8) + (8 - 8)^2\right]$$

$$= \frac{4}{3}\left[\frac{1}{4}\right] = \frac{1}{3}.$$

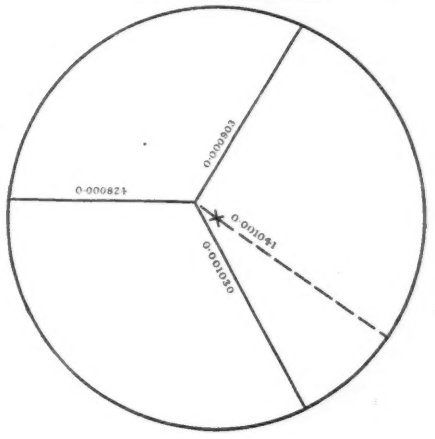
$$\therefore\ S = 8 + \frac{1}{\sqrt{3}} = 8{\cdot}577.$$

Therefore ratio of maximum to mean strain—also the maximum to mean stress, since by Hooke's law, these are proportional to strains—is $8.577 : 8 = 1.072$. This is about the order of stress distribution for a good compression test, viz., 7 or 8 per cent. above the mean.

An actual example of stress distribution is now given. The

FIG. 12.

Showing method of obtaining ratio of Maximum to Mean Stress across a section perpendicular to axis.



curves—Figs. 10 and 11—show the load-strip curves and the stress-strain diagrams for this case.

Nickel steel. Stress distribution. Load 8.3 tons.

Strip readings in $\frac{1}{1000}$ths of an inch:—

Strip 1	1.90
,, 2	2.31
,, 3	6.09

The ratio of the radius of action of the strip to the radius of the specimen was measured and found to be = 6.89.

The mean extension of the strips was 3.43in.

The differences from the mean are:—

(1)	−1.53
(2)	−1.12
(3)	+2.56

The surface extensions are:—

$$(1)\ 3.43 + \frac{-1.53}{6.89} = 3.43 - 0.222$$

$$(2)\ 3.43 + \frac{-1.12}{6.89} = 3.43 - 0.163$$

$$(3)\ 3.43 + \frac{2.66}{6.89} = 3.43 + 0.386$$

Then

$$(S - 3.43)^2 = \frac{4}{3}\left\{(-0.222)^2 + (-222 \times -0.163) + (-0.163)^2\right\}$$

$$,, \quad = \frac{4}{3}(0.493 + 0.0362 + 0.0266)$$

$$,, \quad = \frac{4}{3} \times 0.1121 = 0.1496$$

$$S = 3.43 + 0.387.$$

$$\text{Therefore } \frac{\text{Maximum stress}}{\text{Mean stress}} = \frac{3.43 + 0.387}{3.43} = 1.1127.$$

Fig. 12 shows a method of estimating the plane of maximum stress. The three strip readings are set off to scale from a point and a circle drawn in to pass through these lines. This method has not been used by the author, but it seems to be simple. Substituting in the formula is very easy.

APPENDIX IV.

The Method of Gripping Specimens and a Test of Ordinary "Vee" Grips.

In order to determine the effect of the ordinary "Vee" grips in producing excentric loading, and so to compare that method of

securing specimens with the spherical seats and screwed specimens, two experiments were made upon a long mild steel specimen. The overall length of the specimen was about 15in. and the diameter of the test portion 0.846in. Sphingometer readings were taken upon the middle 4in. The angle θ is the angle between the line of minimum displacement and strip 1. Between the tests the specimens were removed from the grips and replaced in the same position in the machine. This was done in order to determine if the "Vee" grips would line up similarly in two consecutive tests. It will be seen that such was not the case, as the two tests differ considerably.

Test 1.—At a load of 5 tons on the specimen, the strip extensions, recorded in one-thousandths of an inch were :—(strip 1) – 0.737 : (strip 2) 4.145 ; (strip 3) 3.592 ; which gave a ratio of maximum to mean stress of 1.211. $\theta = 10.3°$.

Test 2.—At a load of 5 tons on the specimen, the strip extensions, recorded as above, were :—(strip 1) – 3.934 ; (strip 2) 11.248 ; (strip 3) – 0.649 ; which gave a ratio of maximum to mean stress of 1.575. $\theta = 39.5°$.

The axes of bending were not widely different, but the stress distribution varied greatly. It therefore appears that this method of gripping the specimen is unsatisfactory for elastic failure tests.

LETTERS TO THE EDITOR.

(We do not hold ourselves responsible for the opinions of our correspondents.)

INTERCONNECTION OF ENGINEERING SOCIETIES.

SIR,—Engineering in its progress has been divided into numerous branches which, as time passes, become more and more defined and distinct. In consequence there has appeared from time to time the necessity of forming new societies in order to give adequate attention to the details of the respective branches. The founders of new societies are naturally inspired in their work by the opinion that their objects cannot be obtained from any existing society. There is, however, a great danger that, in their enthusiasm, they may overlook the fact that some other societies have similar objects, and that they might strengthen their cause by recognising the value of the sympathy and influence of such societies. All technical engineering societies have at least one object in common, *i.e.*, "To direct the great sources of power in Nature for the use and convenience of man," and this ideal should of itself be sufficient to ensure a common interest and harmony.

There is also a danger of misunderstanding arising between new and existing societies. A dignified interest on one part might, on account of insufficient opportunity for discussion and explanations, be mistaken for an unwarranted intrusion or interference.

The engineering industry is a busy one, and has, as a rule, very little time to spare for the discussion of social questions. Individuals leave such affairs alone probably under the impression that somebody else will attend to them. Would it not, therefore, be a good policy for one of the existing great institutions to form a small advisory board, whose privilege it would be to confer with other bodies and to form, as it were, an "interconnector" between the various sources of power? It would be formed of experienced men, with a knowledge of the objects of all existing societies and institutions. Having authority to approach founders of any new movement, and interesting themselves in the objects, they could do much to prevent clashing of interests, and thereby advance the science of engineering.

The Institution of Civil Engineers embraces all branches of engineering in one powerful society, and is, therefore, in the best position to form a board to act as mediators.

Those who attended the meetings of the new society, which is at present called "The Institution of Mining Electrical Engineers," will recognise that the writer has them in mind in making the above suggestion. To those who were not present it is sufficient to say that a diversity of opinion existed on a suggestion to modify the title into "Electrical Mining Society," or some other title which would be less likely to be confused with the title of the parent Institution of Electrical Engineers.

The objects of the new society have been clearly defined and explained in the technical Press, and it is plain that they are not entirely covered by the great mining institutions or by the Institution of Electrical Engineers. They aim at the education and advancement of the engineer in charge of electrical plant in mines and also the education of manufacturers, mining engineers, and managers, in matters relating to the electrical requirements, specifically for mines.

Whilst many individuals thus affected are engineers who are members of the existing technical societies, there are others who by reason of previous training would not be eligible for election into the established institutions. But as it is one of the primary objects of the new society to induce men to qualify as capable electrical engineers for mines by study and examination, there is every reason to expect that it will eventually be a training ground for the Institution of Electrical Engineers and the Institution of Mining Engineers.

It is suggested that an Advisory Board to act as an interconnection between engineering technical societies could at the present time do much good service, and the movement in connection with electricity in mines is a case in point requiring immediate consideration.

December 29th. H. W. C.

CENTRIFUGAL FORCE.

SIR,—When two parties to a discussion cease to enlighten each other, it is time that discussion should cease. Mr. Sayers has failed to enlighten me and I have failed to enlighten him. The deduction should be obvious ; yet a last word may be said.

Your correspondent seems to deprecate the practice of asking why, and implies that we should be content to ask how. But Sir Isaac Newton was not content to ask how the apple fell, but why. The search for "why" has been the principal cause of the progress in science.

The discussion about the meaning of the word acceleration has, after all, nothing to do with centrifugal force, simply because there is no acceleration, no change of velocity, no change of direction, no alteration in stress. Furthermore, the revolving mass has no rectilinear velocity to change because it has no rectilinear motion. It cannot have, because its path is a geometrical or Euclidian circle. Mr. Sayers writes: — "Its rectilinear velocity is constantly changing in accordance with Newton's second law. Rate of change of momentum is proportional to the impressed force, and takes place in the direction in which that force acts, for there is a force of constantly changing direction acting on it." There is here some wild confusion of thought. If the second law applies then there must be change of momentum, and, if so, then work must be done ; but it is an obvious fact that there is no change in momentum, and that no work is done.

No more unhappy example could have been cited than the pendulum. The pull of gravity on it is not radial, and does work continuously, accelerating and decelerating the bob, the velocity of which—and its *vis viva*—is constantly varying.

The statement that "Why the radial force does no work on the stone is answered by the fact that it accelerates positively and negatively, or accelerates and decelerates equally and evenly," I do not in the least understand, and I do not think your correspondent does. If it has any meaning, it tries to convey the impossible concept of a mass moving slower and faster at the same time.

I thank Mr. Sayers for referring me to Perry's book. I have no difficulty in measuring centrifugal force. I know the base on which the formula for calculating it, $\frac{Mv^2}{32.2\,R} = C$, rests. All this has nothing to do with the fact that an assumption is made, that a radial force can be balanced by a tangential force, which the human mind refuses to accept as possible. I am not arguing that this assumption should not be made. Unless we do make it, indeed, we cannot calculate the value of centrifugal force in any given case. I take exception to the attempts which are made to explain away a dynamical absurdity of suppositions. The truth is that we are unable to explain centrifugal effort except on the assumption that two forces at right angles can balance each other. Not one of your correspondents contradicts this. Mr. Sayers implicitly accepts it. The proper attitude to take is to say that centrifugal force cannot really be explained, because the only possible explanation involves a contradiction ; but that by making certain algebraic assumptions we can calculate the radial effort. I am quite in accord with your correspondent when he says that science has only managed so far to answer questions concerning How? This is not one of them.

I hope I have made my position clear, and yet some of your correspondents have, I fear, failed to understand me. Put into plain language, they say that a pull is put on the string because a tangential force is exerted by the stone. They admit, as I understand them, that this tangential effort is the sole cause of the radial effort. All the text-books say so. I say that this proposition demands the formation of a concept inconceivable by the human mind.

December 22nd. PATER.

[We do not see that anything would be gained by continuing this discussion.—ED. THE E.]

THE FAILURE OF TECHNICAL EDUCATION.

SIR,—So much has been heard, such unanimity has been apparent among the "eminents" of our own and other professions, on the desirability of technical education, that the bare suggestion that now—after some years working—it has proved an unqualified failure, will come as a complete surprise to those who have not been brought into painful contact with its bankruptcy.

Technical education is a failure, and that not because the younger members of our profession have been slow to use the opportunities which have been presented to them, still less because they have been deficient in energy, desire, and real ability, but because of the continued frigidly unsympathetic attitude of manufacturing engineers and those who control the machinery of employment towards the young engineer who to mere craftsmanship has added a comprehensive understanding of the fundamentals of scientific engineering.

What is the situation at the present moment? Young men, after having served full time in the shops, and subsequently having added an engineering course at one of our technical colleges, find it more difficult to obtain employment than those who are entirely innocent of any technological knowledge.

We must exempt cases where immediate success follows the pressure of great influence, though the extent to which the unscrupulous use of undue influence is prevalent in the engineering profession might well afford subject for inquiry on the part of disinterested shareholders. No ; those to whom I refer are engineers who have no other recommendation than the demonstrated evidence of their brains, ability, and thorough training. We must also exempt employment in the capacity of lecturer or demonstrator at a technical institution, for if it is conceded that the only place for technically and practically trained men is on the staff of a technical institution, then is the failure of technical education admitted, and the complete alienation of active engineering and technical education a proven fact.

I could name instance after instance within the narrow range of my personal knowledge of young men who have passed, with profit and distinction, both through the shops and engineering college who, at the end of their courses, have been compelled to accept employment on a salary less than they could have obtained —perhaps were obtaining– immediately on the completion of the workshop training and prior to the technical training. In many cases the fully trained engineer must, initially, give his services for nothing, and in others obtain wages which an errand boy would refuse, and which would insult a labourer.

In almost all cases the initial salary would fall far short of the interest at 5 per cent. on the capitalised value of his training.

Surely it is not too much to say, that if there is no place in commercial engineering for the thoroughly trained man in which he may legitimately expect a minimum living wage, then either organised technical education is a disastrous failure, or else British engineers in high places have utterly failed to appreciate the value of such men.

I say British advisedly, for things are not so in Germany or the United States.

When I think of the hundreds of able young men who, after graduating in the workshops, enter our technical colleges each year ; who do so only at great sacrifice on their own part and on that of their parents ; when I think of the added sacrifice of all that draws youth from the study ; when I think of the ultimate reward which will be theirs, the cruel disillusion, the crushing disappointment, I am filled with loathing and contempt for the unctuous souls who preach "technical education" in public, and so successfully throttle its devotees in their capacity as the "illustrious heads" of great engineering concerns.

Cardiff, December 23rd. G. LEWIS.

SOHO WORKS.

SIR,—In your issue of the 17th you give an article on the Soho Foundry, by C. H. Wall, M. Inst. M.E It is a most interesting account, especially to those who, like myself, were trained there, I having been an indentured apprentice, and my father, who passed away at the age of eighty-five in June last, assistant works manager.

I want to enlighten Mr. Wall on one point, that of the method employed in heating cranks for shrinking on to the shafts. The plan mentioned by Mr. Wall was not introduced till about the seventies. At or near that time I had to take in hand a crank and shaft from the machines, having previously helped on other cranks which were placed in the centre of a wood pile in the big erecting shop. I considered this a clumsy and dirty job, and hit upon the plan of the lead bath, and, getting the consent of Mr. Walton, the coppersmith, I carted my crank and shaft to his shop and effected a splendid job, and, besides, the crank did not take a quarter the time to finish off. This was the first start of the lead bath, and I was interested to know that it was an accepted plan afterwards. Apologising for taking up your valuable space,

JAS. FORBES.

London, December 29th.

CALENDARS, DIARIES, &c., FOR 1910.

MANY excellent wall calendars, diaries, pocket-books, &c., for the year 1910 have reached us. From Henry Simon, Limited, of Manchester, we have received the usual handy desk or wall calendar with large daily tear-off sheets.—A similar calendar, which is intended for hanging on the wall, has also been received from E. R. and F. Turner, Limited, of Ipswich.—The Western Electric Company, of Norfolk House, Victoria Embankment, has sent a tasteful little desk calendar with monthly tear-off sheets.—A desk calendar has been received from the Life Association of Scotland, of 82, Princes-street, Edinburgh ; also a large wall calendar bearing an excellent picture.—Two wall calendars with monthly tear-off sheets have also been received from the Hunslet Engine Company, Limited, of Leeds. A special feature about these calendars is that they are covered with washable gelatine.—Goringe Craddock and Co., Limited, of Wakefield, have sent a exceptionally large wall calendar with monthly tear-off sheets, similar to the one sent out by them last year. — The Ironmonger Diary for 1910, which is issued by the publishers of *The Ironmonger*, of 42, Cannon-street, E.C., is a well-bound and extensive volume, and contains much useful information. —John Smith and Co., of Carshalton, Surrey, have sent us a useful cardboard wall calendar, without tear-off sheets.—From Hamilton Brothers, electrical engineers, Glasgow, we have received a wall calendar, with small monthly tear-off sheets.—A large wall calendar, with monthly tear-off sheets, which is exceptionally well got up, is to hand from the United States Metallic Packing Company, Limited, of 110, Fenchurch-street, E.C.—From Merryweather and Sons, Limited, of 63, Long-acre, we have received the usual attractive wall calendar, having monthly tear-off sheets, and the card on which these are mounted bears some good illustrations of the firm's manufactures.—An excellent combined blotting-pad, calendar, and diary is to hand from the Electrical Power Storage Company, of 4, Winchester-street, E.C.—Another very handy blotting-pad, and, like the former, suitable for office use, is to hand from the Hart Accumulator Company, of Marshgate-lane, Stratford, London, E.—As in previous years, Hayward-Tyler and Co., Limited, of 99, Queen Victoria-street, have issued a handy little pocket diary which contains some information of value to hydraulic engineers.—Cammell, Laird and Co., Limited, of Sheffield, have issued a wall calendar with monthly tear-off sheets, and the card upon which it is mounted bears an attractive picture. —Three exceptionally good wall calendars have been sent to us from Dewhurst's Engineering Company, of Sheffield, each having monthly tear-off sheets, and the cards on which these are mounted bear pictures of a very excellent kind. One of these pictures is of a French village, and it is from a painting by Albert Wallet.—From "Thermit," Limited, of 27, Martin's-lane, Cannon-street, E.C., we have received a very neat little pocket note-book containing some useful engineering and general information and a calendar for 1910 and 1911.—A useful note-book and diary for 1910 is also to hand from Glenfield and Kennedy, of Kilmarnock, Scotland.—A wall calendar having large daily tear-off sheets has reached us from Ashwell and Nesbit, Limited, of Barkley-lane, Leicester.—Alfred Herbert, Limited, of Coventry, have sent us one of their new wall calendars, which is got up in the usual excellent style, having large monthly tear-off sheets, each bearing an illustration of some kind of machine-tool as manufactured at the Coventry Works.—A similar wall calendar having large monthly tear-off sheets is to hand from John Rogerson and Co., Limited, of Wolsingham, Durham.—The "Gloucester" Diary and Director's Calendar for 1910 is to hand from the Gloucester Railway Carriage and Wagon Company, Limited, of Gloucester. This, as is well known, is an exceptionally useful publication, containing among other things a director's calendar, which enables the periodic recurrence of fixed engagements, such as board meetings, to be recorded.—Davey, Paxman and Co., Limited, of Colchester, send a nicely bound pocket diary and note-book, which contains, besides typical illustrations of the productions of the firm, several useful tables, &c.—We have to thank Cammell, Laird and Co., Limited, for a handsome pocket-book and diary. It contains, besides tables, &c., and illustrations of a few of the firm's productions, a note-book of squared paper, and the inevitable coupon.—A very acceptable little book is to hand from W. F. Dennis and Co., of 49, Queen Victoria-street, which contains a calendar for 1910, and some useful data relating to electric and other wires. It is excellently well bound, and its dimensions are such as to allow of it being carried in the waistcoat pocket.—An excellent metal desk calendar provided with monthly and daily cards has reached us from the Atlas Metal and Alloys Company, Limited, of 52, Queen Victoria-street, E.C.

CATALOGUES.

EDMUND COIGNET, Limited, 20, Victoria-street, Westminster.—This is an interesting pamphlet dealing with the Coignet system of armoured concrete construction as applied to mining and other industries.

R. WAYGOOD AND CO., Limited, Falmouth-road, London, S.E.—This is a new catalogue dealing with cranes of all kinds. It is well illustrated and treats of cranes which have been erected for various classes of service.

DAVID JOY AND COOPER, Quayside, Bitterne, Southampton.—From this firm we have received a little booklet having reference to David Joy and Cooper's patented steam assistant cylinder for assisting the valve gear in its work of moving and controlling the main valve.

P. J. MITCHELL, Caxton House, Westminster, S.W.—A well-got-up little booklet has been sent to us by this firm, having reference to thermal storage. The system described is that designed by Mr. Druitt Halpin. The booklet is well illustrated, and contains a considerable amount of interesting information.

CHARLES CHURCHILL AND CO., Limited, 9-15, Leonard-street, Finsbury, E.C.—"Machinery and Tools" is the title of a tasteful little booklet which has been forwarded to us by this firm. It contains views of the firm's workshops, show-rooms, stock-rooms, offices, &c., and each illustration is accompanied by a concise description.

FLETCHER BROTHERS, Limited, Ashton-under-Lyne, Lancashire.—A well-bound catalogue has reached us which deals with standard boiler mountings and steam pipe valves. It contains numerous illustrations showing the various valves and fittings made by the firm. Prices are given throughout, and all other particulars of interest to buyers.

THE CHLORIDE ELECTRICAL STORAGE COMPANY, Limited, 39, Victoria-street, Westminster.—From this firm we have received an interesting pamphlet describing the "Entz" booster, which is employed in conjunction with a battery for dealing with heavy peak loads. The pamphlet deals with this system in a very thorough manner, and there are many illustrations.

WELLMAN-SEAVER AND HEAD, Limited, 47, Victoria-street, London, S.W.—This is an extensive catalogue having reference to chargers for horizontal re-heating furnaces. The catalogue has been compiled to illustrate some of the types of charging machines which the firm has made, and to show the wide range in the size of ingots and slabs handled. The catalogue is printed on excellent paper, and the illustrations are exceptionally good.

BRUCE, PEEBLES AND CO., East Pitton, Edinburgh.—Pamphlet No. 18A has reached us, which gives particulars and prices of large-sized continuous-current dynamos and motors. Very complete lists of weights and dimensions are given ; also lists of outputs, both as motors and generators, for all sizes dealt with in pamphlet, at the usual standard voltages. Motors up to 1500 horse-power are listed, also dynamos up to 1100 kilowatts.

THWAITES BROTHERS, Limited, Vulcan Ironworks, Bradford.—An extensive catalogue has reached us pertaining to metallurgical plant and accessories. Among other things, it deals with water-jacket furnaces, Roots blowers, reverberatory furnaces, hot blast stoves, centrifugal pumps and fans, blowing engines, air compressors, ore hoists weighing machines, ore and coke wagons, ore crushers, crushing rolls, Bruckner roasting furnaces, &c.

ROLLS-ROYCE, Limited, Derby.—The new catalogue which this firm has recently issued on the well-known Rolls-Royce motor car is a unique publication of its kind. Besides containing complete descriptions, specifications, and illustrations of the 1910 chassis, together with testimonials and flattering opinions, the book contains a batch of sporting colour plates reproduced from water-colour drawings by Charles Sykes. These depict the different uses to which the motor car may be put, both in town and country, many of which are worthy of frames.

R. HUNT AND CO., Earls Colne.—From this firm we have received a new catalogue dealing with shafting, pulleys, and power-transmission accessories.

THE EMPIRE ENGINEERING COMPANY, Caxton House, Westminster, S.W.—A neat little pamphlet has reached us which describes and illustrates the Empire petrol or gas engine.

THE BRITISH ELECTRICAL TRADE SUPPLY AND BITUMEN COMPANY, Canal Bank, Trundley-road, Deptford, London, S.E.—This is a small pamphlet dealing with refined Trinidad bitumen.

P. AND W. MACLELLAN, Limited, 129, Trongate, Glasgow.—This firm has sent us a well got up pamphlet, which deals with the Norton ball-bearing jacks and "Sure-drop" contractors' jacks.

TANGYES LIMITED, Cornwall Works, Birmingham.—Catalogue No. 129 has reached us, which has reference to this firm's "T" type gas engine. We have also received the firm's latest list—No. 134—dealing with belt-driven duplex pumps.

THE CENTRAL ENGINE WORKS, West Hartlepool.—Section 7 of this firm's general catalogue has reached us. It gives numerous illustrations of drop forgings made in iron, steel, copper and Munts metal up to 1 cwt. in weight, and for all trades.

ARTHUR R. BROWN AND CO., 54 and 62, New Broad-street, London.—This is an extensive catalogue having reference to gold dredgers, steamships, harbour dredgers, &c. The catalogue contains many excellent illustrations, and each is accompanied by a concise description.

HOLOPHANE GLASS COMPANY, 12, Carteret-street, Westminster, London, S.W.—This is a catalogue dealing with the Holophane system of illumination. Among other things it contains some useful engineering data which should interest those associated with illuminating problems.

ANDREW BARCLAY, SONS AND CO., Limited, Kilmarnock, Scotland.—A well-got-up booklet has reached us, which illustrates and gives particulars of some of the Oddie-Barclay pumps as manufactured by this firm. The booklet is provided with a thumb index, by means of which any specific information can readily be found.

MERRYWEATHER AND SONS, LIMITED, 63, Long-acre, W.C.—A new catalogue has reached us. It deals with all kinds of pumps to be driven by hand or by any kind of engine or other power-producing agent. The catalogue contains numerous illustrations and prices, code words, and other particulars of interest to buyers.

THE MCKENZIE, HOLLAND AND WESTINGHOUSE POWER SIGNAL COMPANY, Limited, 58, Victoria-street, S.W.—The title of a well-got-up little pamphlet to hand from this firm is "All Electric Power Signalling at Yarnton, Great Western Railway." The matter which the pamphlet contains is a reprint of an article which appeared in the *Railway Engineer* for August, 1909.

W. H. WILLCOX AND CO., Limited, 34 and 36, Southwark-street, London, S.E.—From this firm we have received a well-got-up little booklet having reference to "Penberthy" patented injectors. It deals fully with the firm's automatic "Penberthy" injectors, which are for low, medium and high pressures up to 200 lb.; also "Penberthy" auto-positive injectors for high pressures and hot water.

RANSOME-VER-MEHR MACHINERY COMPANY, Caxton House, Westminster, London, S.W.—This is a new catalogue dealing with the Ransome concrete mixer. It is an extensive publication, and is believed to be the most complete catalogue ever compiled relating to concrete mixing machinery. It contains numerous illustrations and nineteen pages are devoted to reports from users of these machines.

THE CLYDE STRUCTURAL IRON COMPANY, Limited, Scotstoun, Glasgow.—This is a well compiled catalogue dealing with structural iron and steel work. Its object is to show in as condensed a form as possible the class of work the firm is prepared to undertake. The catalogue illustrates the various departments of the firm's works, and also various kinds of structures which have been built by the firm in different parts.

DAVIDSON AND CO., Limited, Sirocco Engineering Works, Belfast.—A well-compiled pamphlet has reached us. It contains a partial list of "Sirocco" fans supplied for mine ventilation in Great Britain. The list includes both the powerful surface fans, capable of handling several hundred thousand cubic feet of air per minute, as well as small auxiliary fans which have been erected under ground, and are used for local ventilation, for supplying fresh air during pit-sinking operations.

ALLEY AND MACLELLAN, Limited, Sentinel Works, Polmadie, Glasgow.—A new catalogue, No. 25E, has been issued by this firm which gives particulars of sizes, outputs, and prices of two-crank compound and three-crank triple-expansion "Sentinel" engines. The special features of these engines are clearly set forth. The illustrations show engines direct coupled to electric generators, but attention is drawn to the fact that they can also be arranged with belt or rope pulleys for driving factories, mills, &c.

MANSFIELD AND SONS, Limited, James-street, Liverpool.—This is a catalogue having reference to Mansfield's patented oil-gas apparatus as well as a copy of a pamphlet on Mansfield's well-known oil gas apparatus, which is constructed to generate gas from any kind of oil for commercial, industrial, or domestic purposes where light, power, or heat is required. Three special types are made—namely, (1) for laboratories where Bunsen burners are used, (2) for factories, &c., and (3) for high-pressure lighting. The book contains sectional illustrations of the producer.

SIEBE, GORMAN AND CO., Limited, 187, Westminster Bridge-road, S.E.—A new and well-compiled catalogue has been sent to us by this firm having reference to all kinds of diving apparatus. It is divided into six sections. The first section is devoted to complete sets of diving apparatus, the second to diving helmets and dresses, the third to divers' air hose and the fourth to miscellaneous items of divers' gear. Section five has reference to the firm's electrical department and gives particulars of divers' telephones, electric lamps, exploding apparatus, and so forth. Lastly, in section six, small power driven air pumps, air compressors, receivers and divers' tools, &c., are dealt with.

THE TUDOR ACCUMULATOR COMPANY, 119, Victoria-street, London, S.W.—A new report catalogue has reached us having reference to stationary batteries. This catalogue provides all the data necessary to enable intending purchasers to prepare the preliminary work connected with Tudor battery plants. As a guide for preparing estimates, two examples of estimates are given which contain all items essential for a complete and up-to-date battery plant, and they also show the manner in which the prices are made up. To enable clients to calculate approximately the freight of a battery from English to foreign ports, tables are given showing the approximate weights and dimensions of batteries, including the necessary accessories and spares, packed for shipment, composed of sixty cells, for all the different types contained in the list. The catalogue is a very useful publication.

JENS ORTEN BÖVING AND CO., 9½, Union-court, Old Broad-street, London, E.C.—This firm has sent us a report on the investigation of an electric shaft furnace by Dr. Haanel. This furnace was designed and erected by the Aktiebolaget Elektrometall, at Domnarfvet, Sweden. Since electrodes and charcoal are necessary for the electric smelting or iron ores, chapters have been added descriptive of the manufacture of electrodes and of the latest types of charcoal furnaces, together with appendices on the progress of electric smelting in Norway and Sweden. From the same firm we have also received two pamphlets, and one has reference to the "Elektrometall" iron-smelting furnace and the other to the "Elektrometall" steel-refining furnace. Jens Orten Böving and Co. are the sole agents for the Elektrometall Company throughout the British Empire.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(From our own Correspondent.)

Raw Iron Revival.

THE raw iron trade enjoys fully as good a tone this week as last, though the holidays have necessarily restricted the extent of business done. Consumers seem persuaded that we are on the eve of a sensible revival, and they are therefore ordering in advance of requirements, so as to anticipate increased prices as much as possible. The upward movement in prices at Glasgow and Middlesbrough and on the West Coast is regarded as distinctly seconding buyers' expectations in this district, and local users are not therefore alone in the opinion which they have formed of an early improvement. It would be too much to say that the market is unanimous that a better state of values and demand will be with us soon, some buyers, it must be admitted, still being very cautious as to how far they commit themselves. Nevertheless, it may be very fairly reported that makers at date are in command of the market, and will not sell except at an enhanced rate of 1s. to 1s. 6d. per ton, and some special brands at 2s. per ton. Makers continue their policy of refusing to book forward as far as certain of the manufactured ironmasters and ironfounders desire, believing that prices will further advance, and that their interests at the moment lie in the direction of not filling up their contract books. Another reason which persuades them to this course of action is the expectation which exists of dearer prices for hard coke in 1910, and a report was prevalent on Birmingham Exchange this week that the Midland coke ovens have resolved upon a declared advance of 1s. per ton with the opening of January. On the Exchange to-day (Thursday) the price of South Staffordshire forge iron varied from 45s. to 46s., with a strong tone. Other descriptions were dearer. Part-mine was quoted at 49s. to 50s., best all-mine 85s., and cold blast 115s. Some Northamptonshire makers asked 50s., but business could be done at 2s. less. Derbyshire brands stood at 49s. to 50s., and North Staffordshire at about 51s. upwards.

Finished Iron Business.

Little has been done at the finished ironworks this week, the works having been laid off in most of the localities, if not for the entire week, nearly so. Happily, ironmasters will resume next week more hopefully than up till a fortnight or three weeks ago had been thought likely. The stronger condition of the pig iron market is being watched very carefully by the users of rolled iron and by merchants, both home and export, and should it appear probable that the spurt will take on a permanent character and the upward movement in prices become a fixed market quantity these buyers will immediately rush in and order. Stocks in the hands, alike of consumers and middlemen, are generally extremely low, and will require immediate replenishing in case the finished iron market goes up. There is a rather healthier tone in the bar trade. Marked bars are in fairly good request at the £8 basis, and South Staffordshire unmarked bars are feeling to some slight extent the stimulus which has been communicated to the pig iron section. Merchant qualities were quoted up to £6 to-day. North Staffordshire crown bars remain at £6 10s. at ports.

White and Black Sheets.

An excellent report continues possible concerning the state of the white and black sheet trade. Inquiries are very numerous, and all the rolling mills and galvanising pots are extremely busy, with excellent prospects. Not for a long time has the business looked better than it does to-day. So excellent is demand that it would surprise no one if prices were soon to show a decided advance in respect of white sheets. Prices tend to become firmer, but there is no definite movement, about £11 5s. for 24 gauge corrugated sheets f.o.b. Liverpool being the usual quotation. There is a decidedly better tone in the black sheet branch, and a fair amount of orders have been placed on the basis of £7 2s. 6d. to £7 5s. for doubles. Makers of both white and black sheets reported this afternoon that they could have taken plenty more orders if they had been able to promise delivery, but with contract books already full this was largely impossible.

Advance in Chain Cables.

It is reported in the chain cable trade that the makers of best chains for the Admiralty have had some excellent contracts placed, with the result that they are raising their quotations 5s. per ton.

Steel.

The stronger tone in the steel trade is upheld, and the outlook for next quarter is considered to be better both in raw and rolled material. Makers' order books are receiving some considerable additions, and the mills have good prospects of regular work in front of them. Makers of rolled material are faced by advancing quotations for hematites—a circumstance which is certain to lead to early higher prices for finished steel if it is continued. Prices are given this week as:—Angles, £5 17s. 6d. to £6; girder plates, £6 to £6 2s. 6d.; boiler plates, £7 5s.; joists, £5 15s. to £6; mild bars, £6 7s. 6d. to £6 17s. 6d. Half product bars for the sheet makers are steadily moving up in price, and an advance of 2s. 6d., and in some instances rather more, is now demanded, alike with respect to Staffordshire made bars and Welsh bars delivered into this district for sheet makers' consumption. Bessemer bars have risen to £4 17s. 6d. and Siemens sorts to £5, with the prospect of further strength if continental supplies happily remain off the market as now.

NOTES FROM LANCASHIRE.

(From our own Correspondent.)

MANCHESTER, Thursday.

Prospects in Pig Iron.

ALTHOUGH there was not a large attendance on the Iron Exchange on Tuesday, there was a better feeling perceptible generally. Consumers evinced greater disposition to operate, and as shipments continue heavy and the warrant market firmer, this state of things is reflected to some extent in this centre. Although there did not appear to be much change in Lincolnshire and Derbyshire on spot, there was a marked advance in Middlesbrough brands and all classes of hematite, the second quarter of the year being quoted for higher figures. Scotch was also the turn dearer. Forge iron was about 6d. higher.

Finished Iron and Steel.

In these classes the market has been rather featureless.

Copper, Lead Tin.

Copper: There was no change to note and business was dull. Lead: Sheets steady, but inquiry slow. Tin: English ingots dearer.

Quotations.

Lincolnshire No. 3 foundry, 54s. 6d.; Staffordshire, 53s. 6d.; Derbyshire, 55s.; Middlesbrough, open brands, early delivery, 60s. 9d.; January-March and April-June, 61s. 1d. Scotch: Gartsherrie, 61s.; Glengarnock, 60s.; Eglinton, 60s. to 60s. 6d., delivered Manchester. West Coast hematite, 64s.; East Coast ditto, first quarter, 65s., both f.o.t. Delivered Heysham: Gartsherrie, 59s.; Glengarnock, 58s.; Eglinton, 58s. to 58s. 6d. Delivered Preston: Gartsherrie, 60s.; Glengarnock, 59s.; Eglinton, 59s. to 59s. 6d. Finished iron: Bars, £6 10s.; hoops, £7 12s. 6d.; sheets, £7 12s. 6d. to £7 17s. 6d. Steel: Bars, £6 2s. 6d. to £6 5s.; Lancashire hoops, £7 5s.; Staffordshire ditto, £6 17s. 6d. to £7; sheets, £7 17s. 6d. to £8; boiler plates, £7 5s. to £7 7s. 6d.; plates for tank, girder, and bridge work, £6 5s. to £6 7s. 6d.; English billets, £4 12s. 6d. to £4 15s.; foreign ditto, nominal; cold drawn steel, £9 5s. to £9 10s. Copper: Sheets, £73; tough ingot, £63 10s.; best selected, £63 10s. Copper tubes, 8⅝d.; brass tubes, 7⅞d.; condenser, 8¼d.; rolled brass, 6¾d.; brass wire, 6¾d.; brass turning rods, 6½d.; yellow metal, 6¼d. to 6⅜d. per lb. Sheet lead, £17 per ton. English tin ingots, £152 10s. per ton.

The Lancashire Coal Trade.

The chief feature in this market was the resolution on the part of Lancashire coalowners to advance the official price of house coal on the 1st of January, 1910, by 10d. per ton. The announcement was received with very mixed feelings on 'Change, especially by merchants who did not think the advance warranted. On the other hand, those who have contracts running for this class of fuel welcomed the higher price. In other respects there was little of interest to note.

BARROW-IN-FURNESS, Thursday.

Hematites.

There is a steady trade in hematite iron, although the attention of business men has been largely taken up during the past few days with the holidays. The market is, however, so sensitive at the moment when it is gradually emerging from a period of semi-activity to one of probable briskness that those who have iron to buy, as well as those who have iron to sell, are on the *qui vive* as to the possibilities and trend of the market in the early future. It is generally recognised that users of iron are likely to require largely increased deliveries in the early months of the New Year, and to a great extent sales have been made to cover deliveries up to the end of March, and some business has been done beyond these dates. Prompt sales are few in number, as metal is not available in most cases, and, as a consequence, the stocks of metal which were of late accumulated in makers' yards have been largely depleted, and the stocks held in warrant stores remain as for a few weeks past at 18,260 tons. There are good reports of trade in special qualities of hematite, and prospects that this trade will soon be very much busier. The quotation for ordinary specifications is about 66s. Ferro-manganese is selling in larger parcels, as well on home as on foreign and continental account. The demand for spiegeleisen is also very well maintained. A good demand for the best qualities of scrap iron is maintained. Sales of charcoal iron are well maintained. There is a better trade in native qualities of iron ore, and prices are given at 12s., 14s. 6d., and 18s. per ton net at mines for ordinary, medium, and best qualities. Some large purchases of foreign ores have been made, and, in addition to these, a trade has been opened up with the brown hematites of county Antrim.

Steel.

There is more activity at local steel works of late, and fewer days have been given for holidays than is usual; but the fact is that makers were somewhat behind-hand with their deliveries of Bessemer sorts. It is expected that further orders for rails, tin bars, and other Bessemer sorts will be booked early in the year; but there is not the same prospect in the department of mild steel. The mills have been standing a long time now, although there has been a fair consumption of material in Barrow itself. This for some time past has been supplied mainly by South Wales makers, who, it is understood, are out of the ring.

Shipbuilding and Engineering.

Shipbuilders, who have recently secured some good orders, are still tendering for new work. They are employing more men in the various departments, and expect to be even busier still as the New Year advances. Engineers are also very busy, and they are also expecting new orders.

THE SHEFFIELD DISTRICT.

(From our own Correspondent.)

The Coal Trade—Railway and Shipping Business.

THE railway companies have not, at the time of writing, renewed their contracts for locomotive fuel. Their offer of 6d. per ton advance on last year's rates is not acceptable to colliery proprietors, who stand out for 9d. per ton more, as they anticipate higher values will generally prevail in 1910. Large continental buyers are offering more than the 6d. per ton advance.

Gas, House, Small Coal, and Coke.

Midsummer is the season for arranging gas coal contracts. These were generally made at about 6d. per ton less than for the previous year. The improvements in gas systems maintain the demand against the competition of electricity for lighting purposes, and the more efficient burners employed widen the range of coal suitable for use. House coal has kept fairly steady during the whole twelve months. In November the winter advance of 1s. per ton was easily obtained, and towards the end of December was officially confirmed by announcement from the collieries. Small coal has been a good market during the year. The short time latterly worked in the Lancashire cotton trade does not appear to have much affected the demand for the South Yorkshire grades used in the mills, the price of which has been maintained at 4s. 6d. to 5s. 6d. per ton. Coke has been advancing, for the most part, throughout the year, the price at closing being 12s. 6d. to 13s. per ton for best washed, and 11s 6d. to 12s. per ton for unwashed. These quotations compare with 10s. per ton for best washed, and 9s. to 9s. 6d. per ton for unwashed in the beginning of 1909.

The Iron Market—Advance in Hematites.

A striking contrast is shown between the position of pig iron in 1909 and 1908. In the latter year there was a gradual decrease in price, along with a diminution of stocks. This year closes with a rise in price over the opening of 4s. to 5s. per ton for East and West Coast hematites, while there is a total increase in stocks exceeding 250,000 tons. Hematite prices at present are close on those of January 1st, 1908, when East Coast was 71s. per ton; in December, 1909, they are 70s. per ton; West Coast, January 1st, 1908, 75s. per ton; December, 1909, 75s. per ton. These quotations are not delivered in Sheffield and Rotherham. From this it would appear that some confidence is entertained of improvement in the New Year, and that those who think so are giving their opinion practical support. Rumours of American buying were freely current during the autumn, but very little more than a few thousand tons could be traced as exported, and stocks have still gone on increasing.

Lincolnshire and Derbyshire Iron.

Lincolnshire pig iron, for the most part, has been fairly steady in its course. In January the minimum official quotations were:—No. 3 foundry, 49s. per ton; No. 4 foundry, 48s.; No. 4 forge, 47s.; No. 5 forge, mottled and white, 47s.; basic, 48s. On June 4th No. 3 foundry was 50s.; No. 4 foundry, 49s.; Nos. 4 forge, 5 forge, mottled and white, 49s.; basic, 50s. 6d. On August 20th there was an all-round advance, No. 3 foundry rising to 51s. 6d., No. 4 foundry to 50s. 6d., Nos. 4 forge, 5 forge mottled and white to 50s. 6d., and basic to 51s. 6d. On September 3rd there was a further advance, No. 3 foundry making 52s. 6d.; No. 4 foundry, 51s. 6d.; Nos. 4 forge, 5 forge, mottled and white, 51s. 6d.; basic, 52s. 6d. These quotations remain at the close of December; but for delivery during the first six

months of next year makers require a premium of from 1s. 6d. to 2s per ton on the official prices. There is strong expectation that the early months will bring better trade and improved values. The quotations, which are net and delivered in Sheffield and Rotherham, are those of the Lincolnshire Ironmasters' Association. In Derbyshire irons the year opened with No. 3 foundry at 51s. per ton; in March the price was 49s.; in June 50s. The tendency continued upward, September seeing the price at 52s., which still rules in December. In January No. 4 forge was 50s.; in March, 48s.; in June, 49s., and in September, 51s. The December price is 50s. 6d. Quotations net, and for delivery in Sheffield and Rotherham. Makers are expecting better prices early in the New Year. They are also well sold forward.

The Steel Trades—Railway and Marine Material.

Very few orders of size are on manufacturers' books, and prices of finished material are considerably lower than they were twelve months ago. At the same time there is less unemployment than at the close of last year. The slight revival in shipbuilding has brought a little more activity in marine specialities made in Sheffield, such as forgings, castings, and the like, on which several firms have been moderately well engaged.

NORTH OF ENGLAND.

(From our own Correspondent.)

Cleveland Pig Iron.

THE holidays have naturally interfered with business this week, and have caused shipments to fall off, and stocks to increase rapidly; but that was to be expected, and it has not led to weaker prices. Most of the foundries are closed this week, and that lessens the consumption of Cleveland Nos. 3 and 4 foundry iron considerably, and the quantity of iron sent into Connal's store this month has been the largest reported in any month this year, just as the increase in stock in December, 1908, was the heaviest in that year. From the 24th to the 27th the stock in Connal's was augmented by no less than 4400 tons; but, nevertheless, the prices ruling for all descriptions of pig iron have been this week the highest that has been reported this month, and traders believe that after the elections sellers will have a better time than has been experienced for several months. As makers are already well supplied with orders for execution next quarter, there is no great pressure to sell, especially as the stocks in producers' yards are not heavy. The surplus output seems largely to be going into Connal's store. Holders of warrants are not offering them freely, because they believe they will be able in the spring to sell them to better advantage than at present; they have this week been realising as much as 51s. 5½d. cash for Cleveland warrants, and buyers are prepared to pay 1s. per ton more than this for delivery up to the end of next quarter. This week No. 3 Cleveland G.M.B. pig iron has mostly been sold at 51s. 6d. per ton for early f.o.b. delivery, and 52s. 6d. for delivery over the first quarter of 1910. No. 1 was at 53s. 9d. for prompt delivery, No. 4 foundry at 50s., No. 4 forge at 49s. 9d., and mottled and white at 49s. 3d., with 1s. more for delivery up to the end of March in each case. On Wednesday No. 3 was obtainable at 51s. 3d., and other Cleveland iron prices were down in proportion. Warrants were easier at 51s. 2d. cash sellers.

Hematite Pig Iron.

The spurt in the East Coast hematite iron market is kept up, and it is the chief factor in bringing about a better tone throughout the pig iron trade, as the improvement is known to be genuine, and not induced by speculation. Speculators do not deal with hematite as they do with ordinary Cleveland iron, for there are no warrants. The hematite iron trade of this district is certainly in a satisfactory position once more, makers having lately secured good orders for execution over the next quarter, and, in some cases, over the first half of the year. In the early part of December, and for some weeks prior to that, mixed numbers East Coast hematite pig iron stood at 60s. per ton, but they have gone up rather smartly since, a lot of orders being placed for early execution at 62s. 6d., but 63s. 6d. is now the lowest that will be taken by producers, with 64s. for delivery over January, and 65s. for delivery up to the end of March. These are substantial advances, but makers cannot very well afford to take less when the prices of materials are so high. It will be difficult to turn out mixed numbers at a profit at 65s. where the present charges for ore and coke are levied. In the early part of this month the nominal price of Rubio ore was 17s. 6d. per ton c.i.f. Middlesbrough, now 19s. 6d. is not only asked, but paid, and even 20s. is quoted by some merchants. That alone will increase the cost of production by 5s. per ton of pig iron made. Such is the demand from all quarters for Rubio that the mine owners in the North of Spain can practically dictate their own terms. Consumers of ore are doing their best to obtain suitable ores from other parts of the world, and the tonnage imported from the new enterprises in North Africa has considerably increased this year. Then the cost of making hematite, and, indeed, all pig iron, is enhanced by the raising of the cost of coke. Ironmasters have to pay 18s. per ton for coke delivered equal to Middlesbrough furnaces, that being relatively a shilling per ton dearer than pig iron, for with Cleveland No. 3 at 51s. 6d. per ton, coke in the normal course should be at 17s. Further advances in hematite pig iron will have to be made to enable the ironmasters to secure a reasonable profit on it.

Manufactured Iron and Steel.

It may be taken as an indication of the improvement in trade that more works are in operation now than is usual in Christmas week. More especially is this the case at the steel manufactories, which in some instances were laid off on Christmas Day only. The producers of finished iron are, however, very badly off, and could do with a good many more orders than they are able to secure. No alterations in prices have been made this week, but it will soon become incumbent on producers to quote higher rates, for they have much more to pay for materials than they had at the beginning of the month, both fuel and pig iron having moved upwards. The year closes with the quotations as under:—Steel and iron ship plates, £6; steel ship angles, £5 12s. 6d.; iron ship angles, £7; packing iron and steel, £5 5s.; steel bars, £6; iron bars, £7; steel hoops, £6 5s.; steel strip, £6 2s. 6d.; steel sheets, singles, £7 5s., all less 2½ per cent. f.o.t. Galvanised and corrugated steel sheets, 24 gauge, are at £11 5s. per ton f.o.b., less 4 per cent. Heavy steel rails are at £5 5s. net f.o.b. Nothing further has been allowed to leak out than was mentioned in this column last week about the proposed new steel works to be built on the banks of the Tees by Sheffield capitalists. It has been conjectured that a cutlery manufactory will be started, but that is rather unlikely. Most of the foundries are closed this week, and trade with them is less satisfactory than it is at the steel works, though it is nevertheless beginning to show improvement.

Transporter Bridge over the Tees.

The progress that is being made with the transporter bridge over the Tees at Middlesbrough is reported to be very satisfactory; a good foundation has been found on both sides of the river for the towers, and about two hundred men are now employed on the work, which is being carried out by Sir W. Arrol and Co.

Coal and Coke.

While buying is slow in coal it promises to be brisk as soon as the holidays are over, and prices generally tend upwards. Best Northumberland steam coals are at 11s. per ton f.o.b. and 10s. for seconds, while for best Durham gas coals the price has risen to 11s. 3d. f.o.b., and Durham bunker coals are dearer—10s. to 10s. 9d. f.o.b. being quoted. Coke is moving up in price, foundry sorts varying from 17s. to 18s. per ton f.o.b., and furnace coke is stiff at 18s. per ton delivered at Middlesbrough furnaces.

NOTES FROM SCOTLAND.

(From our own Correspondent.)

The Holiday Arrangements.

THE disadvantages of having separate holiday stoppages of business south and north are still with us, and likely to continue for at least some considerable time. Business communications with England during the past week have been largely futile, and in the course of next week a similar disability will be felt between England and Scotland, particularly in the first two or three days of next week. Much time has been employed in stocktaking, and in many cases the process will have to be completed at the end of the New Year holidays. The iron and steel works, shipyards, and other industrial concerns will be closed, as a rule, throughout next week, and it is not expected that there will be anything like a general resumption of work until the 10th or 12th of January.

The Iron Market.

The Glasgow pig iron warrant market was closed on Monday, but at the re-opening on Tuesday a fair business was done. Indeed, there has been in the last few days of the past week, and in the tone of the market this week indications of the probability of a good business being done in the early weeks of the coming year. Since last report, business has been done in Cleveland warrants from 51s. 5d. to 51s. 1d. and up again to 51s. 5½d. cash, from 51s. 7d. to 51s. 9d. and back to 51s. 3d. for delivery in one month, and 52s. to 52s. 5½d. and 51s. 4d. three months. It has been a feature of the market in recent days, that a moderate amount of business has quickly had the effect of lifting prices.

Scotch Makers' Iron.

Merchants and ironmasters seem well satisfied with the amount of fresh business they have been enabled to entertain in the closing days of the year. They state that Canada, Australia and the Continent have made large purchases of iron, and that the home demand has by no means been inconsiderable. Prices of Scotch pig iron are well maintained. The f.a.s. quotations at Glasgow are, for Govan and Monkland, No. 1, 57s.; No. 3, 55s.; Carnbroe, No. 1, 60s.; No. 3, 57s.; Clyde, No. 1, 62s. 6d.; No. 3, 57s. 6d.; Gartsherrie and Calder, Nos. 1, 63s.; Nos. 3, 58s.; Summerlee, No. 1, 64s.; No. 3, 59s.; Langloan, No. 1, 65s.; No. 3, 60s.; Coltness, No. 1, 85s.; No. 3, 58s. 6d.; Eglinton, at Ardrossan or Troon, No. 1, 59s.; No. 3, 57s.; Glengarnock, at Ardrossan, No. 1, 65s.; No. 3, 60s.; Dalmellington, at Ayr, No. 1, 62s.; No. 3, 57s.; Shotts, at Leith or Glasgow, No. 1, 63s.; No. 3, 58s; Carron, at Grangemouth, No. 1, 64s. 6d.; No. 3, 58s. 6d. per ton. One furnace has been taken off hematite since last report, and there are now 42 making hematite, 36 ordinary, and 5 basic iron, the total of 83 furnaces thus in operation in Scotland comparing with 84 last week and 77 at this time last year.

The Hematite Trade.

There has been further dealing in Cumberland hematite warrants, which have been purchased from 63s. 3d. to 64s. for delivery in three months. These transactions proceed on a favourable statistical position as regards the Cumberland product. In the case of Scotch hematite the market has been quiet but steady, and merchants quote 65s. per ton for delivery at the West of Scotland steel works. The arrivals of hematite ore in the Clyde in the past week consisted of twenty cargoes, nearly the whole of it being from abroad.

Finished Iron and Steel.

There has been comparatively little activity in these departments. Inquiries for steel seem to indicate that a fair business may be anticipated after the holidays in shipbuilding material. The foreign demand at the moment is quiet. In the malleable iron trade the outlook is somewhat indifferent, but the general impression seems to be that business may ere long show some improvement.

The Coal Trade.

The coal market has been quiet this week, mainly because orders up to the end of the year were placed some time ago, and there is little inclination to enter into fresh engagements until after the New Year holidays. For such orders as are in the market prices are firm, ell and steam coal being quoted at Glasgow harbour 10s. to 10s. 6d., and splint 10s. 6d. to 11s. per ton.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Last Week's Coal Trade.

THE members on 'Change were not expectant of any pressure of business, and were not disappointed. For two days there was some degree of buoyancy, and then a little spurt ended it, though the impression left on the old frequenters was that the promise of the future is by no means depressing. The labour market is fairly tranquil, and the coal trade of the New Year has abundant promise. Some surprise was expressed that the Northumberland coalowners had practically settled their eight hours' dispute with their men. This lessened the expectation that northern trade might flow this way; but ample bookings have been secured, and sellers were able in several instances to get an advance. One of the problems in front is: Are coalowners to continue troubled with the stormy weather? Even last week it was most trying, and sent pitwood up in price, as well as causing great scarcity.

Latest Coal Quotations. Cardiff.

Quotations remain, very little work doing until Wednesday. Best large steam, 16s. 3d. to 16s. 6d.; seconds, 15s. 6d. to 16s.; ordinaries, 14s. 6d. to 15s.; best drys, 16s. 3d. to 16s. 6d.; ordinary drys, 14s. 6d. to 15s. 3d.; best washed nuts, 13s. to 13s. 6d.; seconds, 12s. 6d. to 13s.; best washed peas, 12s. to 12s. 6d.; seconds, 10s. to 11s. 6d.; very best smalls, 9s. to 9s. 3d.; best ordinaries, 8s. to 8s. 6d.; cargo smalls, 6s. 9d. to 7s. 6d.; inferior sorts, 6s. to 6s. 6d.; very best Monmouthshire black vein, 15s. 3d. to 15s. 6d.; ordinary Western Valleys, 14s. 6d. to 14s. 9d.; best Eastern Valleys, 13s. 9d. to 14s. 3d.; seconds, 13s. to 13s. 6d. Bituminous coal: Very best households, 17s. to 18s.; best ordinaries, 15s. to 16s.; No. 3 Rhondda, large, 17s. 3d. to 17s. 6d.; smalls, 10s. to 10s. 6d.; No. 2 Rhondda, 13s. to 13s. 6d.; through, 9s. 6d. to 10s.; smalls, 7s. to 7s. 6d. Patent fuel, 15s. to 15s. 6d. Coke: Special foundry, 24s. to 27s. 6d.; foundry, 19s. to 20s.; furnace, 17s. to 17s. 6d.; pitwood, 19s. 6d. to 20s.

Newport Coal.

Very little was done at the opening of the market this week. Even the last despatch of the week was affected by holiday conditions. Only 3000 tons were exported on closing day. This week only approximate prices can be given. Very best black vein, 15s. to 15s. 3d.; Western Valleys, 14s. 3d. to 14s. 6d.; Eastern Valleys, 13s. 6d. to 14s.; other kinds, 12s. 6d. to 13s. 3d.; best smalls, 7s. 3d. to 7s. 9d.; seconds, 6s. 6d. to 7s.; inferiors, 6s. to 6s. 3d. Bituminous: Best house coal, 15s. to 15s. 6d.; seconds, 14s. to 14s. 6d. Patent fuel, 15s. to 15s. 3d. Coke: Foundry, 18s. to 19s.; furnace, 17s. to 17s. 6d. Pitwood, ex-ship, 19s. 6d. to 19s. 9d. Owing to the short week the coal despatch was only 57,075 tons foreign and 17,097 coastwise. Heavy stock of coal is lessening.

Swansea Coal.

Little business done and very small attendance. It was stated that many of the collieries were idle, but the outlook is good. Little business now until the New Year. Latest prices:—Best malting anthracite, large hand-picked, 23s. to 24s. net; second malting, large, 21s. to 22s. net; big vein, 17s. 6d. to 19s. 6d., less 2½; red vein, 13s. to 13s. 6d., less 2½; machine-made cobbles, 23s. to 24s. net; Paris nuts, 25s. 6d. to 26s. net; French nuts, 26s. to 27s. 6d. net; German nuts, 25s. to 26s. net; beans, 18s. 6d. to 19s. 6d. net; machine-made large peas, 11s. to 12s. 6d. net; fine peas, 10s. 6d. to 11s. net; rubbly culm, 5s. 9d. to 6s., less 2½ per cent.; duff, 2s. 6d. to 3s. net. Steam coals: Best large, 17s. to 18s.; seconds, 14s. 6d. to 15s.; bunkers, 9s. 6d. to 10s. 6d.; small, 7s. to 9s., all 2½ per cent. less. Bituminous coal: No. 3 Rhondda, large, 18s. to 18s. 6d.; through, 14s. 9d. to 15s. 6d.; small, 10s. 3d. to 10s. 6d. Patent fuel, 13s. to 13s. 6d., all less 2½.

Iron and Steel.

As a holiday week in greater part, prices were not much in evidence. At the Swansea metal market, Siemens steel bars were quoted at £4 17s. 6d., the same as Bessemer. Neither heavy nor light rails were quoted, figures, it is assumed, remaining the same. Pig iron prices were as follows:—Hematite mixed numbers, 62s. 9d. cash and one month; Middlesbrough, 51s. 5d. cash and one month; Scotch, 57s. cash and month; Welsh hematite, delivered, 67s. 6d. to 68s. 6d.; East Coast, 67s., c.i.f. Other quotations:—Copper, £60 17s. 6d. cash, £61 18s. 9d. three months. Lead, English, £13 17s. 6d.; Spanish, £13 7s. 6d. Spelter, £23 2s. 6d. Silver, 24½d. per oz.

Tin-plate.

Though it was a short week, limited to four days, the quantity of tin-plate sent from the works was a large one, 87,542 boxes, showing that the workmen had worked with considerable vigour, knowing that a time of slackness was at hand. The shipments amounted to 67,908 boxes, and stocks now are close upon 125,000 boxes. The outlook continues satisfactory, and after the holiday influence is gone trade may be expected to be resumed with briskness. Prices remain, with some exceptions; the ordinary Bessemer and Siemens plates are quoted the same as last week, namely, 12s. 7½d. to 12s. 9d. at Liverpool, but at Swansea quotations, I.C. 20 × 14, 112 sheets, 108 lb., 12s. 9d.; wasters, 11s. 6d.; ternes, 28 × 20, 112 sheets, Siemens primes, 22s. to 22s. 3d. Large, altered:—C.A. roofing sheets, £8 10s. to £8 15s. per ton; big sheets for galvanising, £8 7s. 6d. to £8 10s.; finished black plates, £9 17s. 6d. to £10 per ton; galvanised sheets, 24 g., £11 5s. per ton; block tin, per ton, £153 15s. cash, £156 5s. three months.

Llanelly.

The majority of the works are well placed for orders, and a marked improvement has taken place in the bar trade. There has not been much competition with America and Germany, and strong hopes are entertained that dumping will not be so rife in the New Year as it has been in the old. Outlook is stated to be distinctly favourable and collieries have been working well, and the port seems to have had less trouble than the others through the weather. Railway enterprise in connection with the anthracite collieries is expected to be in evidence in the district.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MESSRS. E. R. CALTHROP AND PARTNERS announce their removal from 3, Crosby-square, to Eldon-street House, Eldon-street, London, E.C. The telephone number and cable address remain the same, namely:—Avenue 4360 and "Raillerais, London."

MESSRS. HOOPER AND SPEAK give notice that they have taken into partnership Mr. Rowland Fielding, and that the firm will in future be known as "Hooper, Speak and Fielding." The offices of the new firm will, on and after the 7th January, 1910, be at 3, London Wall-buildings, E.C. The firm's telegraphic address and telephone number will remain unchanged.

REPORTS from Canton indicate an opening for nitrate of soda as a fertiliser, a British firm there having made a successful beginning in an experiment to introduce it as a substitute for sewage. At Chinan Fu, the capital of Shantung, a German firm recently made experiments with artificial fertilisers, and his Majesty's Consul suggests that there are great possibilities for potassium salts in that province. But the mass of Chinese farmers are so poor and so ignorant that the prospect of generally introducing chemical fertilisers must be considered as still far off.

THE remarkable thermal conductivity of carborundum, states a contemporary, has recently received an interesting application in the manufacture of moulds for cooling aluminium to rapidly chill the cast metal. Aluminium, as, moreover, do all other metals, becomes much denser when it is cast in a carborundum mould, which rapidly extracts heat from the cast metal. By this there is produced a sort of temper which gives the metal a much finer and denser structure. Sand moulds, on the other hand, being poor conductors of heat, cool the metal very slowly, and in consequence allow all the constituents of the metal the time necessary for crystallisation and segregation. The manufacture of these moulds consists, according to the inventor of the process, in dry mixing fine carborundum powder with sugar and clay. The mixture is moistened with sufficient mortar to give a plastic mass to which is given the shape of the desired mould; this is then baked. These moulds also possess the advantage of being much lighter than metallic moulds, and of being readily broken, crushed, reduced to a fine powder and reagglomerated again with a different shape.

A SEPARATE unit type of reinforced concrete wall construction was used last year in building the power-house of a small hydro-electric plant at Newton Falls, Ohio. The pilasters are of monolithic concrete, while the walls between them are hollow and are built of inside and outside thin concrete slabs, which were set before the pilasters were poured, so as to be keyed into them. The slabs were reinforced with No. 28 gauge expanded metal and were made in sizes that could be handled conveniently. Their outer surfaces were corrugated by laying ⅜in. round rods in parallel lines on the surface of the fresh concrete when the slabs were cast and pulling them out after the mixture had taken its initial set. These corrugations were designed to give a good bonding surface for the plaster coat which was applied to the walls after they had been erected. The slabs were allowed to cure and were then placed on edge in proper position. Vertical form boards were placed for the pilasters, extending beyond the surface for the monolithic work, so that the slabs rested against them. The inside faces of the pilasters were moulded against form boards placed in the air space between the wall slabs, and were wired to the outside forms after the pilaster reinforcement had been placed. The inside boards also acted as spaces to keep the slabs the proper distance apart. This distance varied somewhat, but 8in. was the minimum.

NOTES FROM GERMANY, FRANCE, BELGIUM, &c.

(From our own Correspondent.)

Rheinland-Westphalia.

IN raw and unfinished iron a tolerably good business continues to be done on home and on foreign account. The tendency all round is firm, though quiet, comparatively few fresh orders being secured. In girders there has been more life shown than was expected for this quarter. Competition is keen, both from abroad and among inland producers. The Cologne and Düsseldorf section of West German iron merchants resolved on an immediate rise of M. 5 p.t. for bars, hoops, and plates; other sections of the Union are likely to do the same. Both among producers and dealers the opinion prevails that spring trade will be animated. Official accounts from December 10th show list rates to be as under:—Raw spathose ore, M. 10.20; roasted ditto, M. 15; Nassau red iron ore, M. 11.50 per ton net at mines; spiegeleisen, 10 to 12 per cent. grade, M. 60; white forge pig, Siegerland and Rhenish-Westphalian brands, M. 55; iron for steel making, M. 56 to M. 58; German Bessemer, M. 58 to M. 60; basic, M. 48 to M. 50, free place of consumption; Luxemburg forge pig, free Luxemburg, M. 44 to M. 46; the same for foundry purposes; No. 3, M. 47 to M. 49; German foundry pig, No. 1, M. 56 to M. 58; No. 3, M. 55 to M. 57; German hematite, M. 57 to M. 59, all per ton free at works. Good merchant bars, common quality, M. 98 to M. 104; iron bars, M. 122.50 to M. 125; hoops in basic, M. 122.50 to M. 125; steel plates, M. 106 to M. 112; plates in basic for boiler making purposes, M. 116 to M. 122; sheets, M. 120 to M. 125; drawn wire in iron or steel, M. 127.50, all per ton free at works.

Production of Pig Iron.

According to figures given by the Union of German Iron and Steel Masters, the production of pig iron in Germany, including Luxemburg, was for November of this year 231,926 t. foundry pig, 33,254 t. Bessemer, 715,332 t. basic, 92,118 t. steel and spiegeleisen, 46,421 t. forge pig. From January 1st to November 30th of this year output was as follows:—Foundry pig, 2,260,743 t.; Bessemer, 374,085 t.; basic, 7,516,866 t.; steel and spiegeleisen, 1,002,075 t.; forge pig, 600,394 t.

The Coal Market in Germany.

There is no change to report in the coal trade, the demand being pretty extensive for most sorts. The Rhenish-Westphalian Coal Syndicate resolved to maintain the present reduction in the output for coal, coke, and briquettes during January, 1910, although the demand for house and for engine fuel has generally increased.

Austro-Hungarian Iron Market.

According to reports given lately, the business in iron and steel has been dull and decreasing, and figures show a falling off against last year. During November of this year sales of the United Austrian ironworks have been as follows:—Bars and sectional iron, 258,564 q., or 2934 q. less than in 1908; girders, 102,306 q., or 22,382 q. more than last year; heavy plates, 38,677 q., or 3316 q. less than in 1908; rails, 44,528 q., or 60,872 q. less than in 1908. Output since January 1st of this year was in bars and sectional iron, 2,967,963 q., or 476,672 q. less than last year; girders, 1,251,996 q., or 41,822 q. more than last year; heavy plates, 892,540 q., or 8708 q. less than in 1908; rails, 853,287 q., or 205,883 q. less than in the year before. The market for coal is very firm, and in coke demand has perceptibly increased. Deliveries in brown coal in December were higher than in the corresponding month last year, and figures at the end of this quarter will be more satisfactory than was at first expected.

Firm Tone in Belgium.

Business in the various departments is well maintained. Signs of improvement have even been perceptible in some branches, and the outlook is fairly bright. The Belgian Steel Convention has raised the prices for all descriptions of manufactured iron 3f. p.t. from January 1st, 1910. Demand and inquiry on the Belgian coal market have remained lively, and are improving against previous weeks.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, December 22nd.

THE urgent inquiries that are being made for Bessemer and basic pig, as well as for malleable and low phosphorus iron, point to a coming demand which will not be delayed much after the first of the year. Steel irons are particularly wanted. Foundry and forge irons are at present inactive. Consumers are working up their material for steel products very fast, and are requesting prompt shipments on orders placed. The supply of billets and sheet bars is about absorbed for the first quarter of the year. Orders for the second quarter will soon show themselves, and the lowest quotation for to-day is 29 dollars at Pittsburg, an advance of .50 dollar, with a probability that 30 dollars will soon be reached. The plate and structural mills are being crowded to make deliveries according to contract. Buyers who have placed their contracts can count on deliveries up to May or probably later, but the new buyers who are coming into the market are told that it is practically impossible to deliver them any steel before June 1st. The structural and plate mills are crowded to the limit of their capacity, it being understood, however, that gaps are left which will enable manufacturers to accommodate emergency buyers. It is estimated that these mills have work now for five months ahead. Notwithstanding the efforts made to preserve prices at present levels, the extraordinary demand has jeopardised present prices, and advances may be forced next month. All kinds of crude material are very strong. The unsettling factor in the market is the large amount of new work that is constantly coming up. The American Bridge Company has booked 600,000 tons of material for this year. The average daily booking of business by the United States Steel Corporation for this month has been 40,000 tons. Demand is coming from all quarters. Building requirements are very heavy.

Hardware manufacturers are heavy buyers of raw material. Engineering plants constructing heavy machinery have been delaying the placing of orders for spring, and several inquiries recently made from these sources lead manufacturers to believe that they will come into the market next month. The new municipal building of this city is to be erected soon, and the lowest bid of seven to furnish the ironwork and stone was 5,895,000 dollars. A great deal of municipal building is being arranged for throughout the larger cities of the country. These requirements cannot be met in time for spring construction, and the authorities who have been authorising the projected work have been informed of the difficulty of getting material before midsummer. Total sales of copper this month, 17,991 tons for export. The production of copper last year, according to figures just published, was 875,849,129 lb. Total domestic and foreign, 1,095,700,123 lb., which is just a trifle in excess of 1907.

ACCORDING to the *Railway News*, the Great Western Railway Company is about to arrange for the reconstruction of a portion of a bridge over the river Severn at Gloucester.

BRITISH PATENT SPECIFICATIONS.

When an invention is communicated from abroad the name and address of the Communicator is printed in italics.

When the abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent-office Sale Branch, 25, Southampton-buildings, Chancery-lane, London, W.C., at 8d. each.

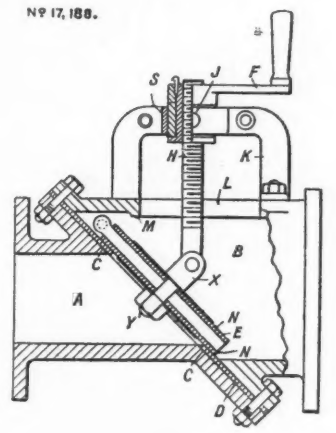
The first date given is the date of application; the second date at the end of the abridgment is the date of the advertisement of the acceptance of the complete specification.

Any person may on any of the grounds mentioned in the Acts, within two months of the date given at the end of the abridgment, give notice at the Patent-office of opposition to the grant of a Patent.

STEAM GENERATORS.

17,188. July 23rd, 1909.—IMPROVEMENTS IN STRAIGHTWAY VALVES, Stewarts and Lloyds, Limited, of Nile-street, Birmingham.

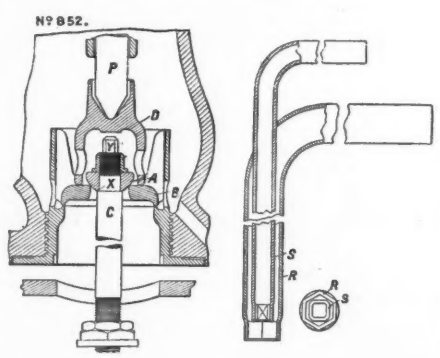
The casing is made in two parts A and B, flange-jointed at an angle of about 45 deg. to the axis. The bore of A is that required to pass the desired volume of fluid, the part B is made of larger internal diameter, in order to expose a portion of the face of the inclined flange of A, for the purpose of forming a valve seat C, which may be covered by a sheet of india-rubber or similar substance D, which not only serves to make the joint between the casing parts, but also forms a readily renewable valve seating, which is especially useful when mill-pulp is to be handled. The valve disc E is pivoted above the orifice to the casing member B, so as to swing on to its seat, or up into a horizontal position, the upper part of B being enlarged and recessed to accommodate the disc when in the latter position, and keep it clear of the line of flow. The valve is operated by means of a hand wheel F, keyed to a nut, through which works a screw spindle H, pin-



jointed to the valve disc E. To permit the spindle to swing in accordance with the motion of the disc the nut is rotatably secured in a frame S, which in turn is mounted on trunnions J in a cavity formed in the bridge K, which latter is conveniently constructed in two halves held together by bolts. The aperture L in the casing, through which the spindle H passes, is preferably made so large that when the valve is closed sediment and the like deposited in the part B of the casing and in the pipes attached thereto may be washed or otherwise cleared out through it. It is provided upon its under side with a seat M, with which, when the valve is fully open, the disc E is in contact, thereby closing the aperture against the escape of fluid. The valve disc may be faced upon one or both sides with rubber or such like discs N N, which resist the scouring action of sand, and are easily renewable when worn out. Such discs are held down by washers, the whole being secured between the jaw head X and nut Y of the bolt. A modification of the invention is also dealt with.—*December 8th*, 1909.

852. January 13th, 1909.—IMPROVEMENTS IN OR RELATING TO REDUCING AND OTHER VALVES, John Dewrance, of 165, Great Dover-street, Southwark, Surrey.

This invention is primarily applicable to relief valves of the type designed to come into operation either upon the steam pressure exceeding the maximum desired or upon the water level falling below the desired minimum. The valve A, which comes into operation upon a condition of low water being reached, is seated upon the back of the valve B which comes into operation upon a condition of excessive steam pressure being attained. The low-water relief valve A, instead of being formed as a portion of the spindle C which is operated by the float lever, is formed separately therefrom; the valve being supported upon a shoulder

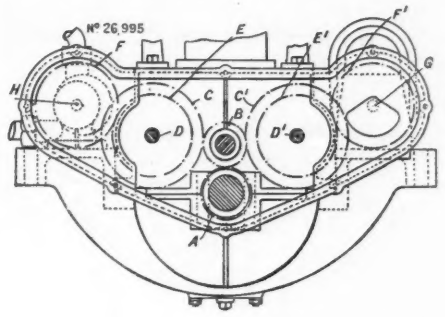


X formed on the spindle, against which shoulder the valve is held by means of a nut. The upper extremity of the spindle projects beyond the nut and terminates in a squared or similarly formed end Y. The high-pressure relief valve B is held down upon its seat by means of a bridge piece D which stands astride of the low-water relief valve nut and spindle end, the bridge piece being held down by means of a spindle P, which passes through a guide and connects, in the usual manner, with a weighted lever. In the event of either of the valves becoming defective by reason of wear or otherwise, the cover of the valve chest or casing is removed and with it the weighted lever and holding down spindle P. The bridge piece D having been withdrawn, two box spanners are applied, one (S) to the square end of the low-water relief valve spindle, and the other (R) to the nut which serves to hold that valve upon the spindle. The nut may now be unscrewed, whilst the spindle C is held against rotation. Upon the removal of the nut, the low-water relief valve A is free to be withdrawn, and thereupon the high-pressure relief valve B may be lifted out or may be re-ground to its seat.—*December 8th*, 1909.

INTERNAL COMBUSTION ENGINES.

26,995. December 12th, 1908.—IMPROVEMENTS IN THE VALVE GEAR OF INTERNAL COMBUSTION ENGINES, *Firmin Brückert, engineer, of Ferrière la Grande, in France.*

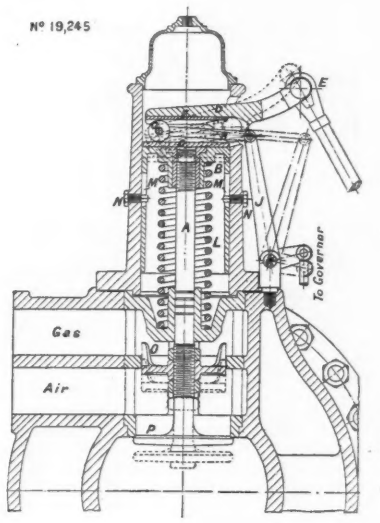
According to this arrangement the valve gear is driven by means of intermediary toothed pinions, the central one of which pinions is mounted on an auxiliary shaft having its axis out of line with those of the camshafts of the motor. On the main shaft of the motor is fixed a toothed wheel A which gears with a central pinion B, mounted on an auxiliary shaft lying between the line drawn



through the camshafts D D¹ of the motor which carry the driven pinions C C¹ on the one hand, and between the pinion of the main shaft by which this auxiliary shaft is driven, on the other hand. By this arrrangement it is claimed a great reduction of the wear and tear of this gear is attained compared with the systems of gearing now in use. On the camshafts D D¹ are further fixed pinions E E¹ which gear with pinions F F¹, the latter being mounted on a pump shaft H and the shaft G of the magneto respectively.—*December 8th*, 1909.

19,245. August 21st, 1909.—IMPROVED MEANS FOR GOVERNING INTERNAL COMBUSTION ENGINES, Herbert Vincent Senior and Frederick Howard Livens, both of Ruston, Proctor and Co., Limited, Sheaf Ironworks, Lincoln.

This invention relates to a device for controlling the admission valve of an internal combustion engine, the object being to obtain this result with the fewest number of parts, at the same time providing a simple means by which the opening of the gas valve can be timed in relation to the opening of the admission valve, both of these being on the same spindle. A is the valve stem which is secured to a guided plunger B, having on its upper side a hardened face C. D is a lever of the first order, the outer arm E of which is operated by a cam shaft in the usual manner. On the under side of the inner arm of the lever D there is fixed a hardened face F, and a roller G is moved between the face F and the face C by means of the twin link H, which is connected to the lever



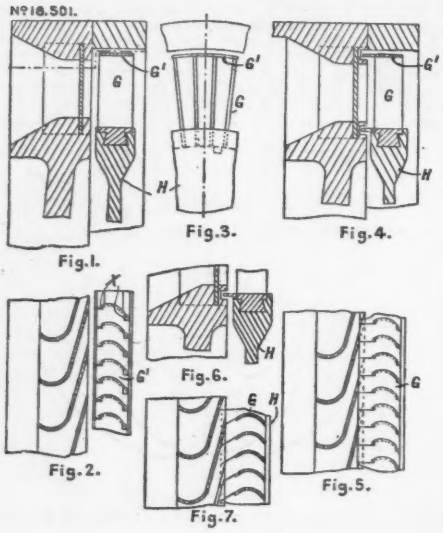
J, which is secured to a rocking shaft K, operated by the governor in any convenient manner. It will be seen therefore that the stroke of the valve is varied according to the position of the roller on the top of the guided plunger. The spring L returns the valve to its seat in the usual way. To prevent the plunger from turning round, slots M M are made in the plunger, in which the ends of the screws N N fit. The gas valve O is screwed on to the spindle A, and the admission valve P is made solid with it; therefore, by screwing the valve O up or down the spindle, on which it is secured, by the locknuts shown, it is evident that the time of the opening of the valve O can be varied in relation to the time of the opening of the valve P, as in practice it is found an advantage for the valve P to open more or less in front of the valve O, in order to clear away the exhaust gases.—*December 8th*, 1909.

TURBINES.

18,501. April 21st, 1909.—SHROUDING AND LEAKAGE PREVENTING DEVICES FOR TURBINE BLADES, James Howden, director, and John Holloway, both of 195, Scotland-street, Glasgow.

This invention relates to improvements in turbines of the impulse and the reaction type actuated by steam, gas or other elastic fluid. Referring to Figs. 1, 2 and 3, the improved shrouding G in its simplest form is produced by constructing each of the rotating blades so that when the blades and distance pieces are fitted in the groove in the wheel H the blades interlock with each other at their outer ends and support each other laterally and circumferentially, and form a continuous and firm band without

riveting that can be ground true and smooth on its periphery and on each side, enabling the wheel with its blades to run truly and steadily with little tendency to vibration, and permitting the shrouding to be brought close to the outer casing with safety, thus tending to prevent the leakage of steam passing over the outer ends of the blades. As shown in Fig. 2, the bent curved and checked circumferential forward part of each blade forming the shroud G^1 bears against the rounded back of each preceding blade and also at both sides enters the rectangular parts cut out for this purpose at X. A further development involving the application to the shrouding of an arrangement of projecting rim which is not

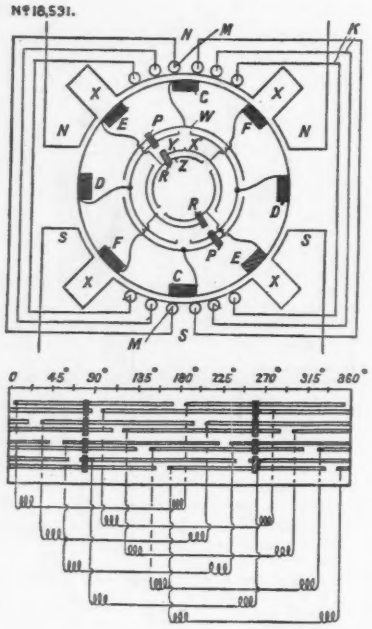


claimed as new *per se* is shown in Figs. 4 and 5, which are respectively a vertical section and sectional plan of a stator with fixed guide blades and the outer part of a rotating wheel with its blades. As shown in said Figs. 4 and 5, a groove or recess, preferably rectangular, is formed both above and below the nozzle orifices, though in some cases only one groove or recess, *i.e.*, the upper one, may be provided. Into these recesses enter a continuous projecting rim on the shrouding at the outer ends of the blades at the side receiving the steam, and a similar projecting rim at the inner ends of the blades on the same side of the rotating disc. The said projecting rims may also be formed on the distance pieces between the blades as shown in Figs. 6 and 7. There are three other illustrations.—*December 8th*, 1909.

DYNAMOS AND MOTORS.

18,531. September 3rd, 1908.—Single-phase Induction Motor, *Giovanni Bestelli and Francesco Spinelli, both of* 14, *Via Lazzro Palazzi, Milan, Italy.*

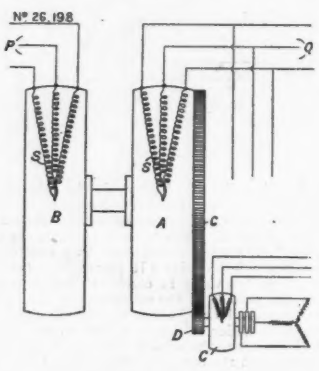
The poles N and S of the stator present two deep recesses



X, inclined at 45 deg. to the axis of the poles. These recesses are somewhat wider than the several coils C, D, E, and F of the armature or rotor, but the poles of the stator must not present any interruption. These poles present a width greater than 90 electrical degrees, half of them being situated on the one side and the other half on the other side of the polar axis. According to the output required of the machine, the winding of the rotor consists of a larger or smaller number of coils, the ends of which are connected with the pairs of semicircles W, X, Y, and Z. The coils are connected in pairs, each pair—independently of the brushes—being independently and completely insulated from the others. Each pair consists of two coils relatively displaced by 90 electrical degrees; in a bi-polar machine they together exactly constitute a cross. The connected coils are fixed to two conjugated semicircles, the breaks in which (like the coils) are situated at 90 deg. one from the other. The two coils of each pair are likewise connected one with the other by means of two brushes P P, R R, these brushes being intended to connect one with the other the two pairs of semicircles corresponding to a pair of staggered coils. The brushes are independently and completely insulated one from the other. The brushes are mounted on the commutator in such a manner that—as shown—they effect the reversal from one semicircle to the other exactly at the moment at which the active wires of the corresponding coils are located opposite the recess X. The stator of the motor is provided with a compensation winding K, the active wires of which are arranged in the holes M. The winding can either be short circuited or closed through a resistance. The lower engraving shows diagrammatically the development of the rotor of a single-phase motor, comprising four pairs of coils, each of which is connected with the corresponding pair of conjugated semicircles.—*December 8th*, 1909.

26,198. December 4th, 1908.—Improvements in and relating to Alternating Current Dynamo Electric Machinery, The Lancashire Dynamo and Motor Company, Limited, of Trafford Park, Manchester; Arthur Pemberton Wood, of "Whitefold," Alan Drive, Hale, Chester; and Robert Stafford McLeod, of 21, Victoria-avenue, Didsbury, near Manchester.

This invention relates to alternating current dynamo electric machines, such as are employed to connect together, say, at a sub-station, two alternating current supply stations of different frequencies, so that both supplies shall be available for a common system of mains, or so that energy may be transferred between the supplies as may be required. The object is to provide an arrangement in which the torque transmitted may be regulated so as not to exceed a predetermined maximum, and so that a considerable departure of either of the coupled stations from its normal frequency is permitted, and so that supplies having frequencies of any ratio may be coupled. Two alternators A and B are provided, the rotors of which are mechanically coupled together; what would under ordinary circumstances be referred to as the stator of one of the machines, say A, but which will be referred to herein as the case A, is, however, made rotatable about the axis of the rotor, and its rotation is controlled by gear-

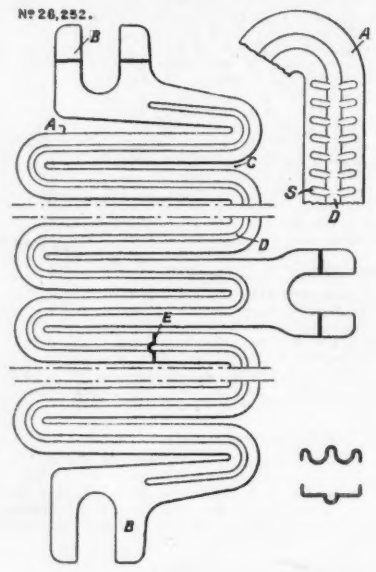


ing it, say, by spur gearing C D to any suitable device, such, for example, as an electro motor, which, whilst permitting rotation of the case, will apply to it a torque which will not exceed a predetermined maximum magnitude; A is the machine with the rotating case, and B is the other machine. The case-controlling device is an alternating current induction motor C. The speed of rotation of the coupled rotors will be that corresponding with the frequency of the supply P to which the stator windings S of the B machine are connected, and if the frequency of the supply Q to which the stator winding S of the A machine are connected corresponds with this speed and the number of poles of the A machine, the case of the latter will remain stationary, and will be held stationary by the torque transmitted to the case by the case-controlling motor. Should the frequency of the one supply or the other change, the effect will be to tend to alter the torque between the case and the rotor of the machine A, and as the case motor is arranged to exert an approximately constant torque on the case, the latter will rotate in one direction or the other, in accordance with the relative effect of the change of frequency, and by so rotating it will accommodate the frequency changer to the altered ratio of the frequencies. There are two other illustrations.—*December 8th*, 1909.

SWITCH GEAR.

26,252. December 4th, 1908.—Improvements in Resistance Grids for Electrical Purposes, Allen West, of 118, Queen Victoria-street, London, E C.

This invention relates to improvements in resistance grids for electrical purposes, its object being to provide in a grid that is stamped sheet iron or from other suitable metal the necessary strength and rigidity, and to render it capable, even when made from thin metallic sheets, of retaining its shape when strongly heated by the current, besides having by reason of its construction an increased radiating surface. The grid A, with the connectors B, is stamped from a single sheet of metal, and when so cut forms a sinuous but continuous length from top to bottom. This is preferably effected by cutting out strips or forming spaces C from alternate sides. A corrugation D is imparted to the grid bars parallel to their edges, which corrugations may be formed when the grid is stamped from the blank sheet, or may be formed by a previous or subsequent operation, depending upon the class of

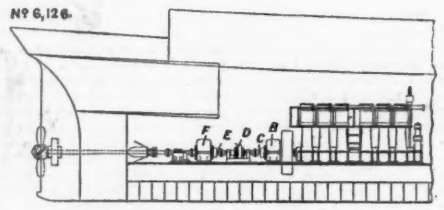


metal, its thickness, or other contributing factor. The invention is not limited to a single corrugation, nor to the particular section shown at E. Any of the sections shown in the right-hand bottom corner may be employed, or any modification thereof, without departing from the spirit of the invention. The top right-hand engraving shows a modified form of corrugation, in which the middle corrugation D has a series of longitudinal strengthening corrugations S, forming a herring-bone type of indentation, the whole corrugation running substantially parallel to the bars of the grid.—*December 8th*, 1909.

SHIPS AND BOATS.

6126. March 15th, 1909.—Improvements relating to the Propulsion of Ships and the like, Charles Day, of 45, Scotland-street, Glasgow.

This invention relates to the propulsion of ships in which the propelling power is delivered from the prime mover to the propeller at times directly and at times by electric transmission. An internal combustion engine may be employed—which is shown as having six cylinders, but which may be of any suitable design—which engine is coupled, or is adapted to be coupled, direct to a dynamo B. The rotor shaft C of the dynamo, or the engine shaft, is adapted to be connected by a clutch D with the shaft E of the electric motor F, the latter shaft being connected with, or



formed integrally with, the propeller shaft. The internal combustion engine may be constructed and arranged to be capable of being varied in speed from that required to propel the ship at full speed to that required to propel it at half speed. At all ahead ship speeds from full to half direct driving may be employed, but for speeds less than half electrical transmission is made use of, the motor F receiving electrical energy from the dynamo. The electrical drive may also be employed for reversing, the astern speed being not greater than half the full ahead speed, suitable electrical switches and gear being provided. As the propulsive power varies approximately as the cube of the speed, then, with such an arrangement, the maximum capacity of the electrical apparatus may be about one-eighth of the full-speed power of the prime mover.—*December 8th*, 1909.

END OF VOL. CVIII.